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ASEAN Wind 2005

Feasibility Assessment and Capacity Building
for Wind Energy Development
in Cambodia, Philippines and Vietnam

Technical Feasibility Studies
Vietnam

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RISØ	IED	Mercapto	PNOC-EDC	IE	MIME

ASEAN Wind 2005 - Fact Sheet

Main project data

Full project title:	Feasibility Assessment and Capacity Building for Wind Energy Development in Cambodia, The Philippines and Vietnam
Objective:	The main objective of the project is to promote wind energy development and facilitate investments on wind energy projects in The Philippines, Vietnam and Cambodia through feasibility assessment and capacity building.
Start:	February 2005 End: December 2006
Total effort:	64.5 man-month
Contracting Authority:	EC-ASEAN Energy Facility (www.aseanenergy.org/eaef)
Budget / Support:	€ 1 000 000 / € 500 000 by European Community

Tasks

Task 1:	Wind Resource Assessments	RISO	+ IED; PNOC-EDC; IE	(10.5 MM)
Task 2:	Power System Analyses	RISO	+ PNOC-EDC; IE	(7.5 MM)
Task 3:	Policy & Market Studies	RISO	+ IED; Mercapto; PNOC-EDC; IE	(9.5 MM)
Task 4:	Technical Feasibility Studies	RISO	+ PNOC-EDC; IE	(10 MM)
Task 5:	Economic Feasibility Studies	IED	+ RISO; PNOC-EDC; IE	(7 MM)
Task 6:	CDM Project Studies	Mercapto	+ All	(5.5 MM)
Task 7:	Financial Framework	IED	+ All	(5.5 MM)
Task 8:	Dissemination	RISO	+ All	(4.5 MM)

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Preface

This report documents part of the work and the output of the activities under the Projects Task 4: Technical Feasibility Studies and forms the Project Deliverables no. 15.

As part of the present Project, technical wind power feasibility studies and analyses have been performed for four selected sites – two in Vietnam (one grid connected and one island system) and two in the Philippines (one grid connected and one island system).

The cases form the basis for the studies and have been selected by the local partners (IE and PNOC-EDC respectively) in the very beginning of the project in order to be able to collect one year of local wind data. For various reasons, some of the original selected sites have been changed. The four sites have been all visited by project teams for site inspection and data collection.

The technical feasibility studies have been presented and discussed at the 2-day workshop 24-25 July 2006 in Hanoi with participation of stakeholders from the countries. The present Report presents the studies and the results. The outcome of the technical analyses forms the input for the economic and financial feasibility studies for the same cases within the Project.

The four very different cases illustrate various typical issues for the introduction and integration of wind power. Large scale integration of wind power into a national grid dominated by hydro power generation is illustrated by the Phuoc Minh case in central Vietnam. The integration of wind power into the national grid at the outer end of a relative weak transmission / distribution line is illustrated by the Sta. Ana case in the north of the Philippines. The integration of wind power into an isolated power supply system, mainly intended for supporting a local mining industry is illustrated by the Dinagat Island case in the Philippines. And the integration of wind power into a small, electrically isolated island power system with a potential for growing consumption is illustrated by the Ly Son Island case in Vietnam.

The present report presents the two feasibility studies in Vietnam, while the two cases in the Philippines are presented in a separate report (deliverable no. 14).

The report has been edited by Per Norgaard, Riso, with input from all Project Partners.

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Executive summary

Feasibility studies have been performed for two very different cases in Vietnam within the present Project – the Phuoc Minh mainland case and the Ly Son Island case – selected by Institute of Energy (IE).

Phuoc Minh

The Phuoc Minh site is very well suited for large-scale grid connected wind power development. The site is situated not far from the Chinese Sea in a flat, open gab between two 500 m high mountain ranges, well exposed to the accelerated wind. There is space for at least 100 MW wind farm here and further more a 110 kV power transmission line with sufficient capacity pass through the site.

Since 2005, high quality wind data have been measured and collected by PECC3 from a 60 m mast at the site. The annual average wind speed for 2005 at 60 m height was 7.0 m/s. PECC3 has estimated the annual production for a 2 MW Vestas V80 wind turbine unit (including 10 % wake losses from the wind farm) to 5.3 GWh, corresponding to a wind farm capacity load factor of 30 %.

A 50 MW wind farm should then annually produce around 130 GWh. The wind farm investments for land based large-scale wind farms at easely accessable site are estimated at around USD 1 mill per MW, or USD 50 mill for the 50 MW wind farm. In addition, a new dedicated power substation is needed.

The detailed wind data from Phuoc Minh was not available for the Project. The detailed wind data analysis has therefore been demonstrated on wind data for 2006 provided by IE from a met-mast at the Tuy Phong site, 30 km south-west of Phuoc Minh.

No long term reference wind data series representative for the site was made available for the Project (with measurements during the same period as data collection in this project).

Ly Son Island

Ly Son Island in the Chinese Sea, 30 km from the mainland, has a population of 20 000. The main income is from fishing. The island is powered by diesel generation, operated by the national power utility. The diesel power plant has a capacity of 2 MW. The electricity prices are defined by the Government. The selling prices (750 Đ/kWh) are lower than the production cost (6000 Đ/kWh), and the power plant is operated in the evening only (between 17 and 23) with half of the consumers disconnected every second day on shift. There is a huge need for more power generation and a willingness to pay the full cost for the power, demonstrated by several private power generation units – mainly for business purposes. At least 6 ice factories supplying the fishing industry have their own 100 kW diesel engines in constantly operation – still with lack of ice production.

A 60 m met-mast installed in the beginning of 2006 at a flat and well exposed site at the middle of the island is operated by IE. The various analyses on the Ly Son power supply system have been performed based on a limited amount of data available at that time. The various results are therefore not fully consistent. Only after the formal termination of the Project one full year of wind data has been made available for the Project.

The value of wind power generation in combination with the diesel generation is the reduced diesel fuel consumption compared to pure diesel operation. The amount of diesel fuel reductions have been estimated for various combinations of diesel generators and wind turbines. 24 hours operation and increased load have been assumed. The obtained diesel fuel reduction is very sensitive to the diesel engines ability to operate at constantly low load. The highest fuel reduction (33 %) is estimated by the exchange of the existing old diesel engines with new engines, designed for low load operation. In addition, the new engines are expected to have better performance and lower fuel consumption. If the installed wind power capacity becomes higher than the minimum load, then part of the potential wind power generation can be utilised. At 1 MW wind power capacity only a few percent of the potential wind power can not be utilised.

With investments in 2 new 680 kW diesel generator sets and 3 numbers of 350 kW wind turbines, and with an average fuel consumption of the diesel generators of 250 g/kWh and a fuel reduction of 33 %, the fuel reduction is 80 g/kWh, corresponding to an annual fuel savings of 400 ton with an annual power consumption of 5 GWh. The wind turbine investment is estimated at USD 2 mill per MW. The wind turbines may be installed at the IE met-mast site, less than 1 km from the power plant.

No long term reference wind data for the island was made available for the Project. However, Ly Son meteorological station appears to have data usable for the estimation of the effects of variations in the wind climate at Ly Son from year to year.

1 Technical wind power feasibility studies

The project feasibility study forms part of the decision basis for the initiation and implementation of the project. The results of the study are presented in findings and recommendations. Typically, the feasibility study is divided into a technical feasibility study and an economic & financial feasibility study.

A technical feasibility study of a wind power project typically includes assessment of the following issues:

- The wind conditions
- The power system
- The land issues
- The proposed wind farm
- The organisational issues
- An environmental impact assessment
- The costs and benefits

1.1 Wind conditions

Information on the wind conditions is obvious crucial for the feasibility. The information should include information on

- the geographical distribution of the wind resources;
- the expected annual energy in the wind;
- the variation of the wind energy from year to year;
- the variation of the wind energy over the year;
- the variation of the wind speed over the day;
- the fluctuation of the wind speed within minutes and seconds; and
- the maximum wind speed.

The geographical distribution of the wind resources should identify the most promising areas. The mapping of the wind resources may either indicate the overall wind resources under uniform conditions or indicate the actual local wind resources, taking local effect into account – like orography and surface roughness.

Determination of the wind resources at a given site must be based on at least one full year of wind data. If only one year of data is available, the one year data must be evaluated by correlation to long term reference wind data representative for the site and with data overlapping the actual measuring period. There may be large variation in the wind energy from year to year.

The value of the wind power depends on the correlation of the variations of the wind power to the power needs – variations over the day and over the year. In case hydro power is part of the power generation mix, the power needs is a combination of the power loads and the hydro power available. The hydro power may be restricted part of the year due to lack of water inflow and limited dam capacity.

For a given area, the wind resources may vary a lot with the actual site due to local effects. Micro siting is therefore important.

Wind turbine class	**I**	**II**	**III**	**S**
Vref	50 m/s	42.5 m/s	37.5 m/s	Values specified by the designer
A	$I_{15} = 0.16$			
B	$I_{15} = 0.14$			
C	$I_{15} = 0.12$			

Table 1: Wind turbine classes as defined in the international standard for design of wind turbine constructions, IEC 61400-1, valid only out of typhoon areas. I_{15} is the turbulence intensity @ 15 m/s wind speed. V_{ref} is 5× mean wind speed.

The expected maximum wind speed in combination with the turbulence intensity determines the design wind speed for the wind turbine construction. For areas out of hurricanes / typhoons methodologies to determine the design wind conditions is described in international standards like the IEC 61400-1 and standard classes for the wind condition are defined.

1.2 The power system – integration of wind power

The stochastic and fluctuating nature of the wind and thereby the wind power generation is a major challenge for the integration of a significant amount of wind power in a power supply system. The power system must have the capability and flexibility to handle the fluctuating wind power and constantly maintain the power balance between the actual production and consumption – both if the system is a small isolated system or it is a large national / international system. Stand alone wind power systems are not handled within the present Report.

The actual available wind power cannot be controlled and may not be well correlated to the demand, and the value of the wind power produced is therefore highly dependant on the

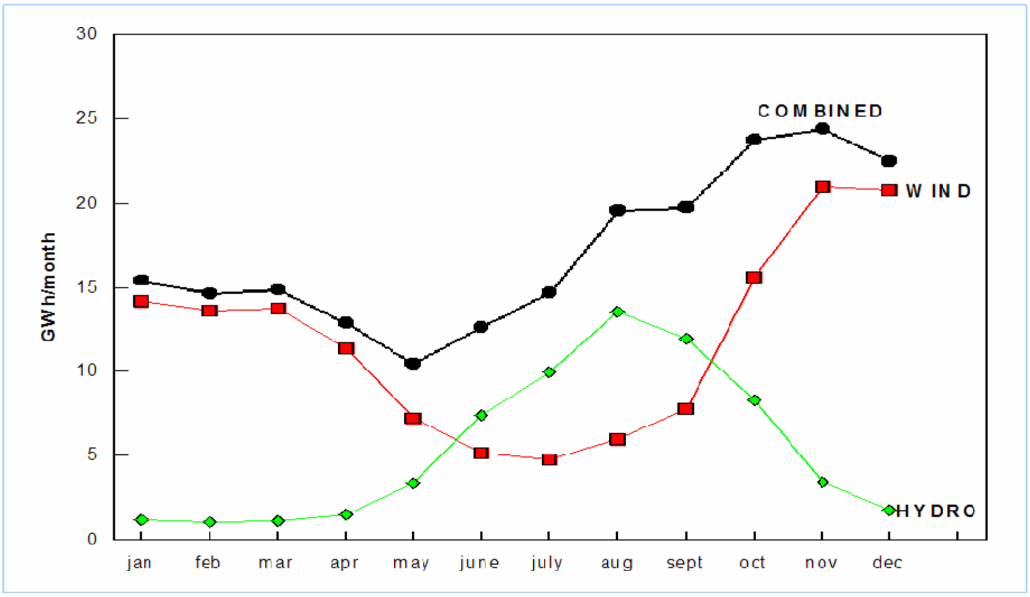

Figure 1: Example of negative correlation between hydro and wind power production maximising the value of the wind power. (Source: MoI, Peter Meier report, 2005)

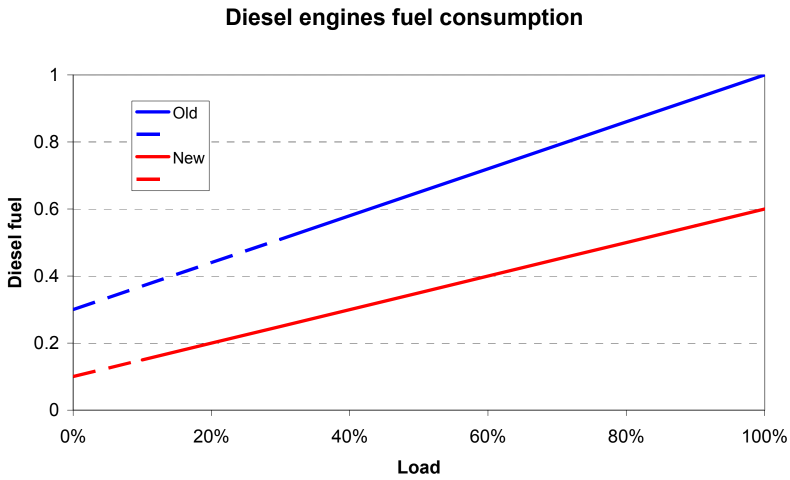

Figure 2: Typical relative diesel fuel consumption for an old and a new diesel engine. The fuel consumption at 'no-load', the slope and the technical minimum load differs. The benefits in terms of 'saved fuel' are highly dependant of the diesel engines efficiency at low load and therefore also of the technical minimum load of the diesel engine.

design of the power system. In case of low wind, the system must still be able to maintain the power balance – either by control of the consumption or by alternative power generation. The control of the consumption may have an impact on the quality – and thereby the value – of the power supply. The alternative generation capability may require investment and operation of additional production capacity – and thereby additional costs. In case of high wind, the system may not be able to utilise all of the available wind power – which will reduce the actual capacity factor of the wind power capacity installed and thereby have an impact of the benefit of the wind power investment.

Wind power and hydro power may form a very good combination because hydro power easily can be regulated very quickly and because the water reservoirs may form excellent seasonal energy storage.

The benefit from wind power in combination with diesel power generation in isolated power supply systems is the diesel fuel that else would have been used to produce the energy produced by the wind turbines. The benefit of the wind power in a combined wind and diesel power supply system can therefore not be measured directly, but has to be calculated by use of a model analysis. The benefits are in high degree dependant on the characteristics of the diesel engines.

1.3 Land issues and site access

The wind turbine units do not occupy much land – 10 × 10 m, but there must be an access road to each wind turbine unit for service and maintenance. The land between the wind turbine units may be utilised for agriculture. However, mainly due to the visual impact no buildings should be closer than approximately 1 km from the wind turbines.

The best site according to the wind resources may be very difficult to access or may be very expensive to achieve, and a compromise must be found.

1.4 Wind farm design

The siting, design and layout of the wind farm will always be an optimisation between the investment costs on the one hand and power generation on the other hand. Issues to take into consideration includes

- land availability and cost of land;
- site accessibility;
- wind power generation;
- cost of the wind turbine units;
- cost of the connection of the wind farm to the power system.

The wind resources will change with the actual sites. Dependant on the distances and wind directions the wind turbine units will take energy from the units in the wake. The cost of the cabling between the wind turbine units in the wind farm will increase with the distances between the units etc.

1.4.1 Wind turbine units

The characteristics of the proposed wind turbine must meet the actual characteristics of the wind at the specific site. The wind turbine must be designed to withstand the expected maximum wind speed at the site – the Wind Turbine Class. And the wind turbine must be designed for a specified lifetime under the actual wind conditions – including the wind fluctuations (express by the wind turbulence intensity). This is taken care of by the national and international certification schemes established for wind turbine units and wind power projects.

In addition, the wind turbine should be optimised to the actual conditions. In general, the following three parameters may vary:

- the rated (maximum) (generator) power capacity;
- the rotor diameter (or rotor swept area);
- the height of the tower (the hub height).

The wind turbines rotor-to-power factor is the ratio between the rotor swept area and the generator capacity. The wind turbines capacity factor is defined as the actual annual production relative to the maximum potential production (full time at maximum production).

The annual expected power production (AEP) by a given wind turbine unit at a given site is nearly fully defined by the combination of the wind turbines hub height, rotor diameter and rated power.

The hub height

The higher surface roughness at the site, the more you will gain in production by increasing the hub height of the wind turbine. But the costs of the wind turbine and the wind turbine foundation will also increase. In general, the higher surface roughness, the higher optimal hub height relative to the rotor diameter. For wind turbines designed for off-shore applications, the hub height will typically be less than the rotor diameter. For wind turbines designed for in-land applications, the hub height will typically be greater than the rotor diameter.

The rotor-to-power factor

The cost of the wind turbine is highly dependant on the rated power and on the rotor diameter. The revenue is highly dependant on the obtained capacity factor. Wind turbines designed for low wind applications (average wind speed < 5 m/s) will therefore typically have a relative high rotor-to-power factor (typically 3 m^2/kW), while wind turbines designed for high wind application (average wind speed > 8 m/s) will have a relative low rotor-to-power factor (typically 2 m^2/kW).

1.5 Organisational issues

The operation and maintenance of wind turbines requires dedicated skills, and an organisation with the sufficient skills must be established. The relate cost of the operation and maintenance is highly dependant of the number of wind turbines that the organisation service. Wind power should therefore be considered only if there is a sufficient large wind power potential – at least 5-10 % of the total power generation capacity in the power supply system.

1.6 Environmental impact assessment

The crucial and difficult environmental impact of wind power is the visual impact. Wind turbines must be located in the open landscape, and they will necessarily always be very visible and dominating in the landscape. The best solution is to install wind turbines in long distance from human activities.

Noise from wind turbines is not a problem for modern wind turbines.

1.7 Costs and benefits

The cost of a wind power project may be estimated with relative little uncertainty. The world market prices of large scale wind turbines designed for grid connection and operation under wind conditions Class I-III are in the range 1-1.5 USD/W, depending on the total capacity of the order (100..10 MW). Local prices are available for the civil and electrical works.

The difficult parameter is the value of the wind power – in specific the capacity value of the installed wind power. In small wind-diesel systems, the wind power capacity will not substitute the diesel power capacity needed, and the capacity value of the wind power is zero. In large power supply systems the installed wind power will have a capacity value, and in systems with hydro power the capacity value of the wind power may be close to 100 %.

2 Technical feasibility case studies

Feasibility studies have been performed within the Project for 4 cases – 2 in Vietnam (one grid connected and one island system), and 2 in The Philippines (one grid connected and one island system). Two of the cases (one grid connected in The Philippines and one island system in Vietnam) have been analysed in more details.

The aim of the technical feasibility studies in the Project has been to strengthen the local capability in performing the relevant technical wind power feasibility analyses. This has been done through illustrative examples, demonstrating methodologies, tools, analyses and evaluations, and with the specific aims to evaluate the technical feasibility of wind power for the region in general and for the site in specific, and to provide economic figures to be used as input for the economic and financial feasibility analyses to follow.

The issues have been studied in various details in the 4 case studies. None of the technical feasibility studies are complete, and should only be seen as illustrative examples.

Site	Phuoc Minh	Ly Son	Sta. Ana	Dinagat
Country	Vietnam	Vietnam	Philippines	Philippines
System	Grid	Island	Grid	Island
Wind power	20-100 MW	0.5-1 MW	30 MW	5 MW

Table 2: An overview of the cases in the study.

Only the case studies in Vietnam are presented in the present report.

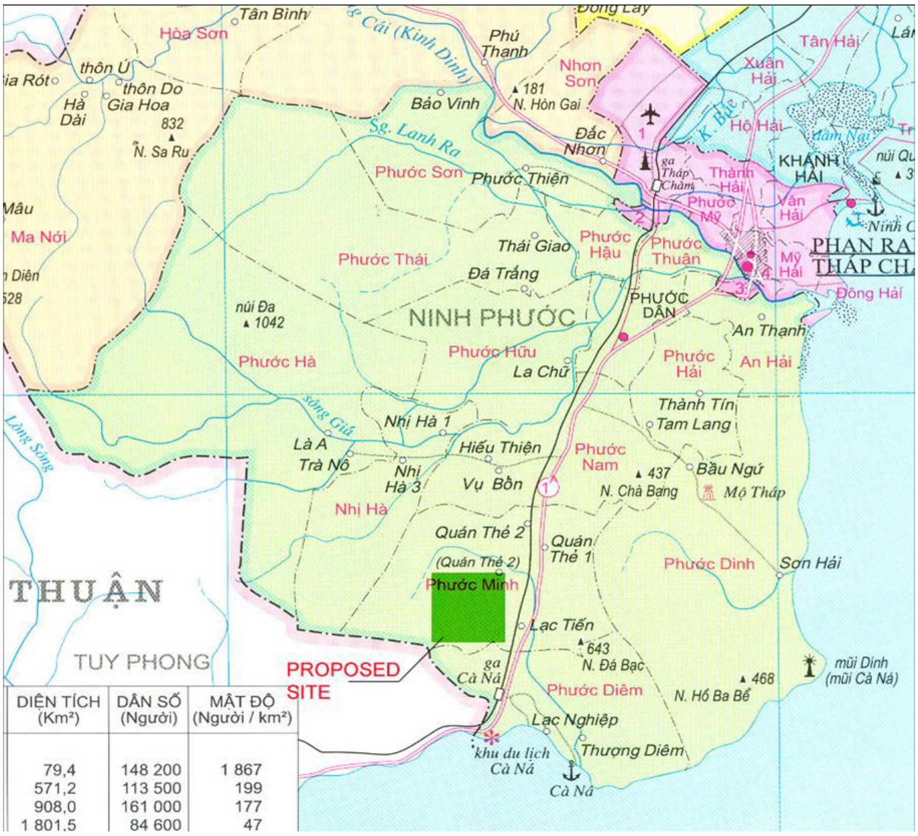

Figure 3: Location of the Phuoc Minh site (the green square). (Source: IE)

3 Phuoc Minh Case - 50 MW grid connected

3.1 National and Local Development Planning

3.1.1 Local Development target

The development directions in coming years are “Agriculture, Fishery – Forestry – Small Family Industry and Services”, in which, the development is focused on industry, small family industry and services such as construction, agricultural, sea products processing facilities (mills, fish processing, fish sauce production …).

Accrding to the general development plan of the district, the following electricity consumers will be developed:

- New residential area with about 1200 households,
- Development of two aquatic product processing enterprises with capacity of 12000 – 14000 tons of aquatic products/year.
- Development of one or two enterprises producing products after salt,
- Installation of two second-step pumping stations (total 10 pumps, N = 330kW),
- Enlargement of salt field from 500ha at present to 800ha,

- Enhancement of capability of existing boats, ship repairing workshops.

3.1.2 Population

Population: total population of the district about 174 240 people (as of end 2004). With 32% of population are ethnic minorities, the traditional culture and Cham culture are paid attention by many people.

3.2 Infrastructure and physical planning

Location: Ninh Phuoc is a coastal district of Ninh Thuan province, with easter longitude of 108o50' and northern latitude of 11o13'. The district is passed by the national road No.1A, North South United railways system. The district center is about 10km far from Phan Rang town. Ca Na is one of promising tourist areas.

Area: Ninh Phuoc district has natural land area of 89 920 ha; accounting for 16.2% of the province's total natural area.

Natural resources: The district has large sea territories, many rare, precious sea products. The area of alluvial ground is large, suitable for salt production.

Traffic: The site proposed for project is about 140 km far from Nha Trang airport, 3 km from Ca Na railway station, 1 km from the national road No.1A, therefore, transportation, construction are very convenient. There are also one small port and a shelter from storms for boats, ships. The existing 1 km soil road width of 6-8 m from the national road 1A to the project site needs to be upgraded when the project is implemented.

3.3 The power system

3.3.1 Electricity demand and load forecast

The estimated electricity demand for 2005, 2010 and 2015 is indicated in Table 3.

Sector	2005		2010		2015	
	A (MWh)	%	A (MWh)	%	A (MWh)	%
Industry - construction	89736.8	51.1	212536.5	60,94	523606	61,81
Agriculture - forestry - fishery	4802.5	2.74	6060.4	1,74	14949.2	1,76
Services - commerce	3991.8	2.27	10888.9	3,12	24941.1	2,94
Lighting and management	67441.9	38.4	99411.3	28,51	235366	27,79
Other demand	9660.1	5.5	19850.7	5,69	48212.7	5,69
Total sales	175633.2	100	348747.8	100	847075	100
Loss + owned use	12662.7		76571.7		185999	
Electricity from grid	188295.8		425319.5		1033074	

Table 3: Electricity demand up to 2005, 2010, 2015 of Ninh Thuan Province.

3.3.2 Electrical grid interconnection

Current status of electric power network in Ninh Phuoc district and project area:

At present, Ninh Phuoc District has one town and three communes with 68 villages, of which 67 villages are connected to the national power grid, accounting for 98.5% of villages and bans (smaller than village).

The main line running through the district is 110 kV line with total length is 30 km and transformer station 110kV/22kV-25MVA Ninh Phuoc.

There is constructed 22 kV line from Ninh Phuoc substation to Ca Na. There are also two substations 22kV/0.4kV-380kVA have constructed at Moi village. These substations are anticipated to supply electricity for Moi village and new planned residential areas.

3.3.3 Existing electricity power sources and power grid of Ninh Thuan and Binh Thuan

Ninh Thuan and Binh Thuan provinces are located on the Centre region of Viet Nam. These provinces are in the process of industrialization and modernisation. The period 2001-2010 is very important to these targets, with the investment for infrastructure; overcome the gloomy economy to gain the high, stable growth rate; change the economic structure, improve quality, productivity and competition to integrate regional, global economy; living standards gradually improve, eliminate hunger and poverty, practise social progress and justice.

Along with the development of economy, the power demand increases rapidly. Local power

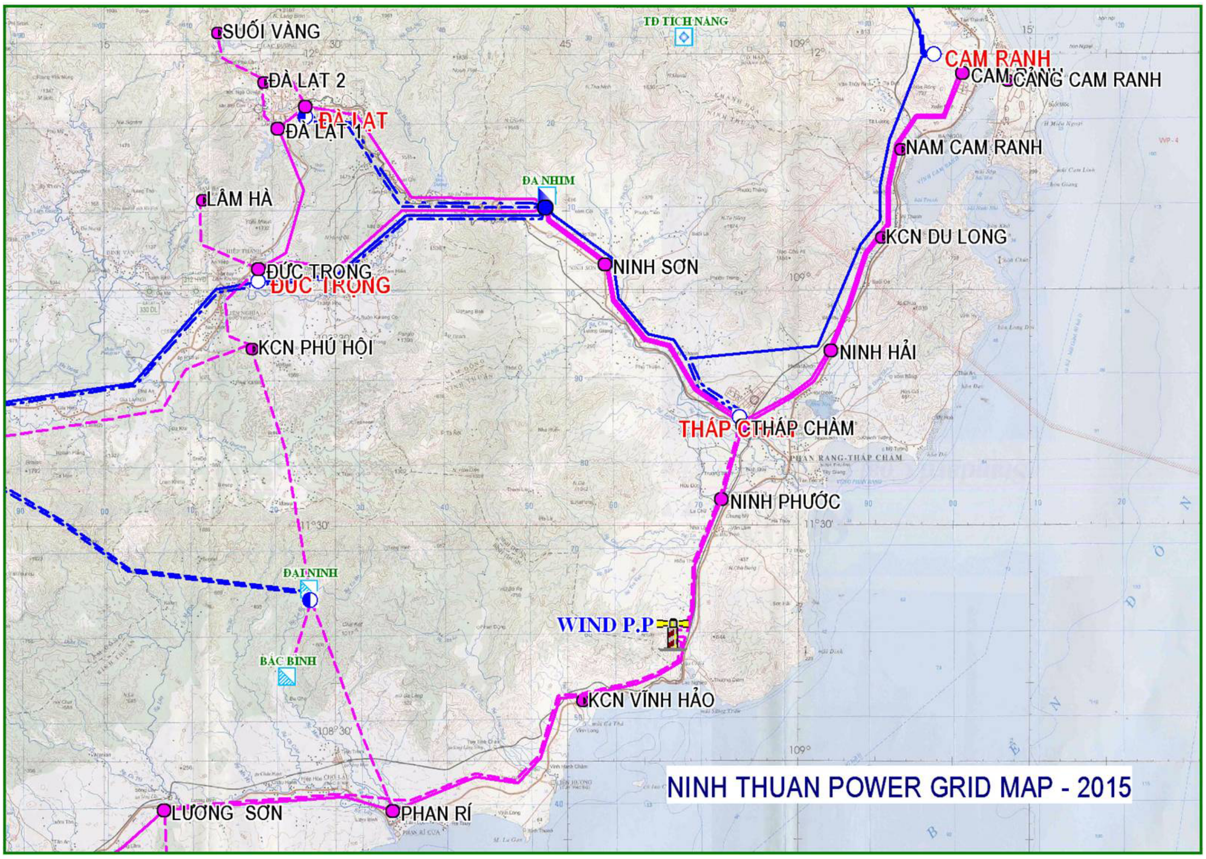

Figure 4: Existing and planned power transmission lines for the Ninh Thuan area in 2015.

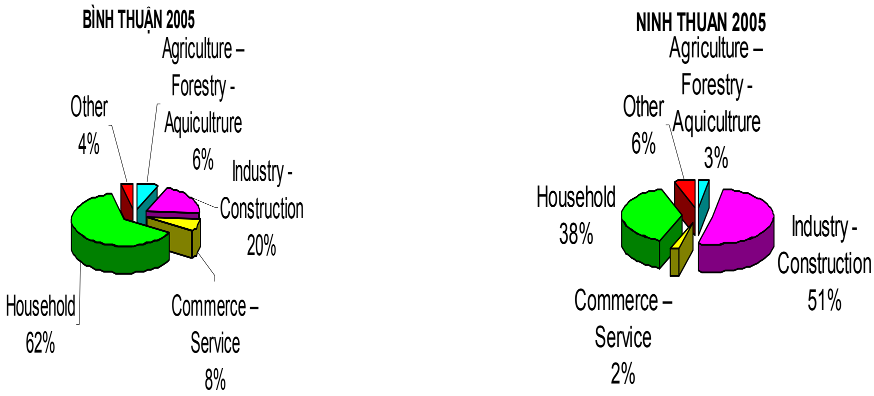

Figure 5: Electricity Consumption Structure in 2005.

plants are always the first choice, and the construction of power plant projects are priority consideration.

The proposed site of Ninh Phuoc wind power plant is near the border of Ninh Thuan and Binh Thuan province, in the headland curves out to the East Sea, where the average wind speed is 9.0 m /s. This plant can provide the power of 100 MW for the provinces, therefore the power plant connection must be considered in the grid of these provinces.

Electricity Consumption		**Ninh Thuận**	**Bình Thuận**
Peak demand	(MW)	59	87
Electricity Consumption	(MWh)	175633	397607
Transmission losses	(%)	7.2	9.0

Table 4: The electricity consumption in 2005 of the two provinces. (Source: Draft Report of "Power Development Plan of Ninh Thuan and Binh Thuan" – PECC3)

At present, there are three main power sources providing 635 MW for the two provinces and others.

Name		**Install capacity (MW)**	**Planned (MW)**
Da Nhim H.P.	(Ninh Thuan)	160	
Wind power	(Ninh Thuan)		30-100
Ham Thuan H.P.	(Binh Thuan)	300	
Da Mi H.P.	(Binh Thuan)	175	
Dai Ninh H.p	(Binh Thuan)		300 (2007)
Bac Binh H.p	(Binh Thuan)		165 (2007)

Table 5: The main power sources in Ninh Thuan & Binh Thuan.

		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum output	(MW)	298	295	292	288	283	278	278	285	292	298	300	300
Minimum output	(MW)	50	50	50	50	50	50	50	50	50	50	50	50
Daily flow	(MWh)	2483	2250	2106	2200	1341	3073	1761	2109	2450	2758	3033	1322
Monthly flow	(GWh)	66	59	66	63	66	63	62	69	71	201	120	66

Table 6: Ham thuan H.p.

		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum output	(MW)	177	177	177	177	177	177	177	177	177	177	177	177
Minimum output	(MW)	20	20	20	20	20	20	20	20	20	20	20	20
Daily flow	(MWh)	1354	1239	1193	1233	800	2333	741	1419	1633	1741	1700	741
Monthly flow	(GWh)	35	32	36	36	38	39	42	45	42	124	74	40

Table 7: Da My H.p.

		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum output	(MW)	159	159	158	157	156	155	155	156	157	159	159	160
Minimum output	(MW)	20	20	20	20	20	20	20	20	20	20	20	20
Daily flow	(MWh)	2535	2492	2600	2800	2167	2720	2032	658	1380	974	1793	2048
Monthly flow	(GWh)	76	68	71	70	74	73	77	80	40	20	73	79

Table 8: Da Nhim H.p.

Name	Location	Capacity (MVA)
Phan Thiet	Binh Thuan	25+40
Ham Tan	Binh Thuan	1x25
Phan Ri	Binh Thuan	1x16
Luong Son	Binh Thuan	1x25
Đuc Linh	Binh Thuan	1x16
Thap Cham	Ninh Thuan	2x25
Ninh Phuoc	Ninh Thuan	1x25
Total		222

Table 9: 110kV Substations supplied two provinces' power demand.

The main 110kV transmission lines are Phan Thiet – Ba Ria 145.6km, Phan Thiet – Ham Thuan: 45 km, Phan Thiet – Thap Cham: 128.7km, Thap cham – Nha Trang: 100 km and Thap Cham – Da Nhim: 40 km.

Currently, power sources and transmission lines can supply safely, confidently the power demand of the two provinces. But, in the future, the power grid and sources must be extended to meet the demand and satisfy the economic development.

3.3.4 Power demand forecast of Ninh Thuan, Binh Thuan province

In Period 2006 - 2015 the average growth rate of Electricity consumption of Ninh Thuan is 19%, Bình Thuan is 17%.

	Ninh Thuan				Bình Thuan			
	2005	2010	2015	2020	2005	2010	2015	2020
Peak demand (MW)	59	122	251	518	87	180	359	729
Electricity Consumption (GWh)	176	401	974	2294	398	889	1899	4148
Transmission losses (%)	7.2	6.3	6.0	5.5	9.0	8.5	8.0	7.3

Table 10: Power consumption. (Source: Draft Report of "Power Development Plan of Ninh Thuan and Binh Thuan" – PECC3; Power Demand forecasts in 2020 are estimated by IE)

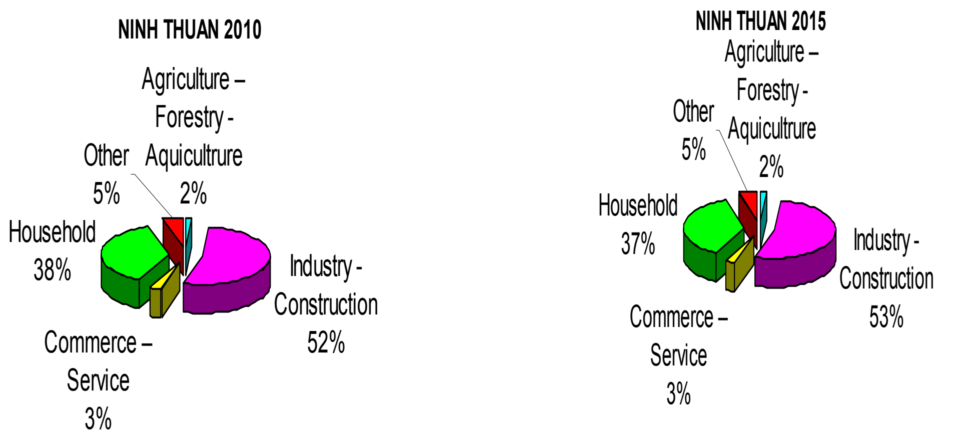

Figure 6: Electricity Consumption Structure of Ninh Thuan.

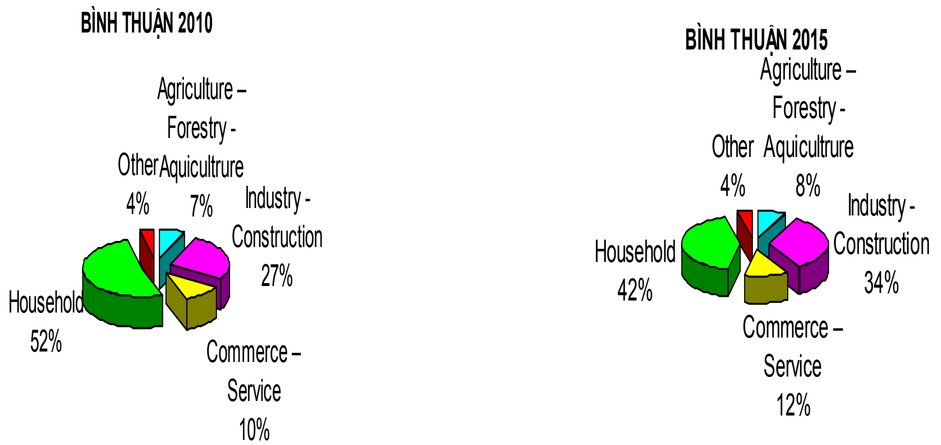

Figure 7: Electricity Consumption Structure of Binh Thuan.

After 2015, the existing local sources will not reach the peak demand of two provinces, some new plants, substations and transmission lines need to be built.

3.3.5 The power development plan of Ninh Thuan, Binh Thuan province

According to the "Power Development Plan of Ninh Thuan and Binh Thuan 2006-2010-2015", some new hydro power plants are constructed, they are Dai Ninh H.p.p- Binh Thuan - 300MW (commissioning 2007), Bac Binh H.p.p - Binh Thuan - 165 MW (commissioning 2007). After 2010, the total local power sources is 1100 MW (all of sources are hydro power), and there is no more hydro power plant will be constructed after 2010 in the two provinces. These Hydro power plants not only supply the power for Binh Thuan and Ninh Thuan but also transmit the power to other provinces. So that, local plants may not satisfy two provinces power demand, especially after 2015, they have to receive electricity from the remote sources.

The power grid will be extended, 267km of 220kV transmission line and 112 km of 110kV transmission line will be built by 2015. And some new substations in the below tables will supply the electricity to the two provinces.

Name	Level	Current state (MVA)	By 2010 (MVA)	By 2015 (MVA)
Thap Cham 220/110 kV	220kV			125
Thap Cham	110kV	2x25	2x25	25+40
Ninh Phuoc + Industry Zone Phuoc Nam 1,2	110kV	25	25+40	40+63
Du Long 1+2	110kV		25+40	40+63

Table 11: Substations in Ninh Thuan by 2015.

Name	Level	Current State (MVA)	2010 (MVA)	2015 (MVA)
Phan Thiet 220/110 kV	220kV		1x125	2x125
Đai Ninh 220/110 kV	220kV		63	63
Phan Thiet	110kV	25+40	25+40	2x40
Mui Ne	110kV		40	40
Ham Tan	110kV	25	25	25+40
Ham Thuan Nam	110kV		25	25+40
Industry Zone (IZ) Phan Thiet	110kV		25	25
IZ Ham Tan	110kV		25	25+40
IZ Ham Kiem	110kV		25	25
Phan Ri	110kV	16	16+40	2x40
IZ Vinh Hao	110kV		25	25
Luong Son	110kV	25	25	2x25
Đuc Linh	110kV	16	16	16+40
Tanh Linh	110kV		25	25

Table 12: Substations in Binh Thuan by 2015.

3.3.6 Proposed plan for connecting wind power plant to the grid

The size of Cana Wind farm is defined about 30 – 100 MW, and supply to local demand. The power may be transmitted with medium (22kV) or high (110kV) voltage. In this report, the wind farm is considered to connect to the 110kV grid.

Currently, the single 110kV (100km, AC185) transmission line from Thap Cham – Ninh Phuoc – Phan Ri - Luong Son crosses the Ninh Phuoc Wind farm.

By 2010, the parallel Second 110kV transmission line will be built.

Two options are put forward:

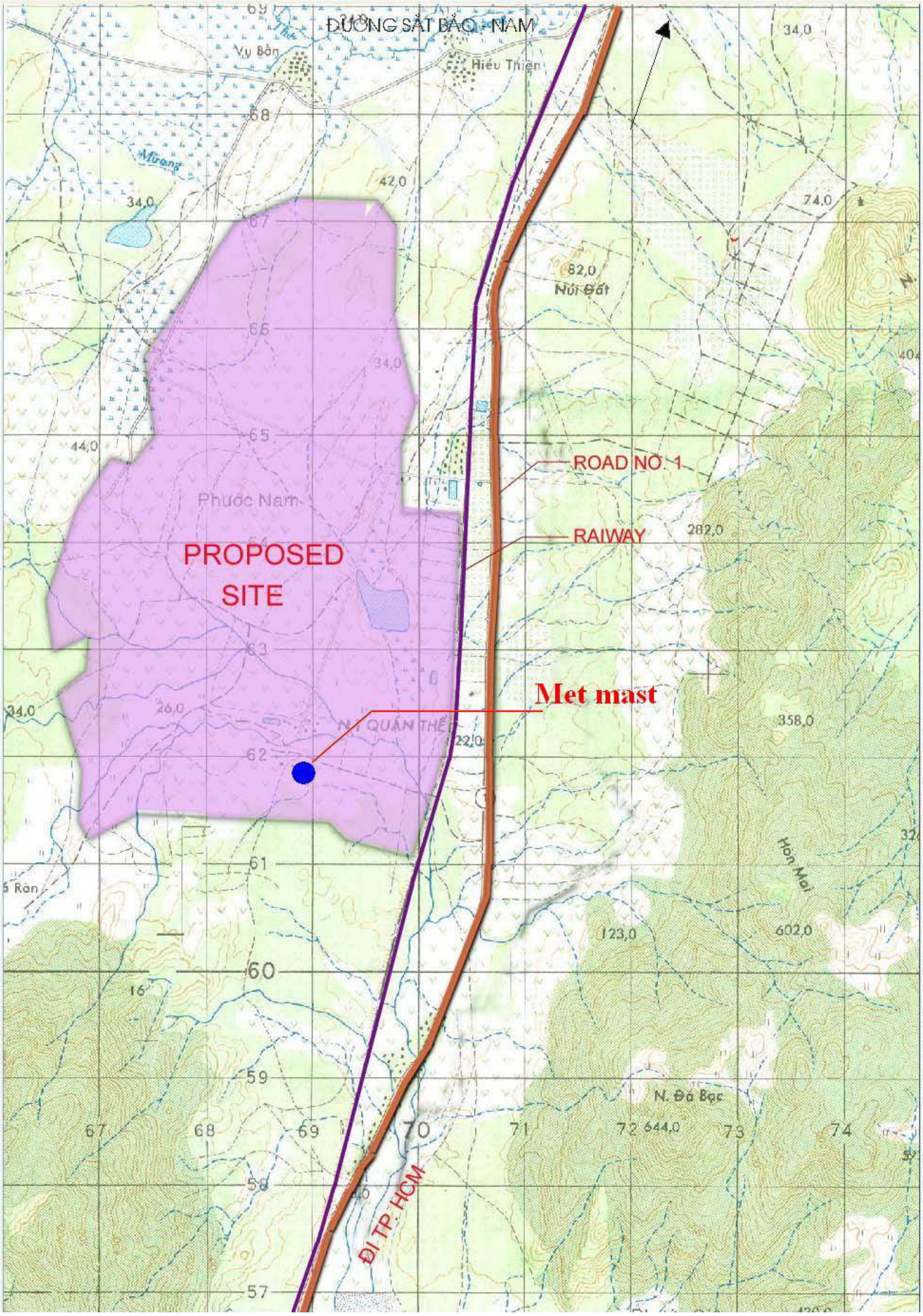

Figure 8: The Phouc Minh site. (Source: IE)

Figure 9: The power sub-station at the Phouc Minh site. (Photo: RISO)

Option 1: connect wind power to 110 kV trans. line from Thap Cham to Luong Son. The 110kV double line need to be built from Wind farm to connected point with 0.5 km length (AC185).

Option 2: Divide the 110 kV double line Thap Cham – Luong Son into 2 parts. Two of 110 kV double circuit lines need to be built from Wind farm to connected point with 0.5 km length (AC185).

The conclusion of connected project:

- Option 1 is suitable for 30-50 MW size of wind PP
- Option 2 is suitable for 100 MW size of wind PP

The selected option for connecting wind PP to the grid will be carried out more detail in the next step.

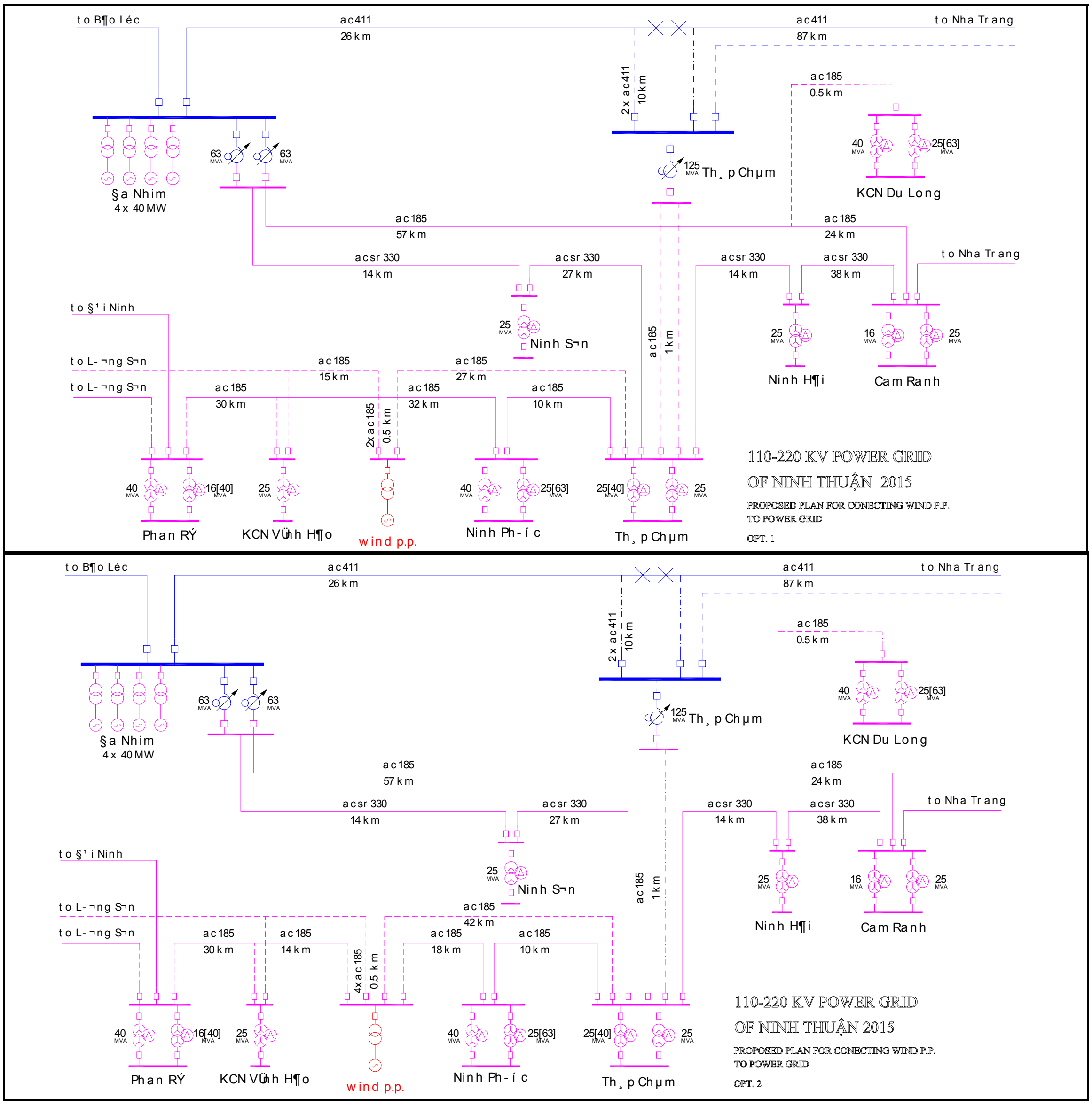

Figure 10: Two options for connection of a wind farm at Phouc Minh to the power supply system – upper: < 50 MW; lower: < 100 MW. (Source: IE)

3.4 Wind conditions

The Phouc Minh site is situated in a north-south oriented gab between two mountain areas with heights of 500 m (Figure 11).

Based on data of system of meteorological stations uniformed in terms of observation medium, observation time calculation methods and self-registering devices, Meteorological Institute carried out calculation of average annual and monthly wind speeds for the whole network of meteorological stations and average hourly wind speeds for those stations which have self - recording devices.

The monthly and yearly average wind speeds measured in Ca Na, by hydro-meteorological stations over 13 year period from 1985 to 1997 at height of 12 m above ground surface, are as follows :

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year
4.5	4.6	4.3	4.3	4.5	4.2	4.4	4.5	4.4	4.5	5.1	5.7	4.7

The wind conditions have been measured for a period of one year in 1998-99 at Ca Na – 10 km south of the Phouc Minh site (Figure 12). The monthly average data observed are indicated in Figure 13.

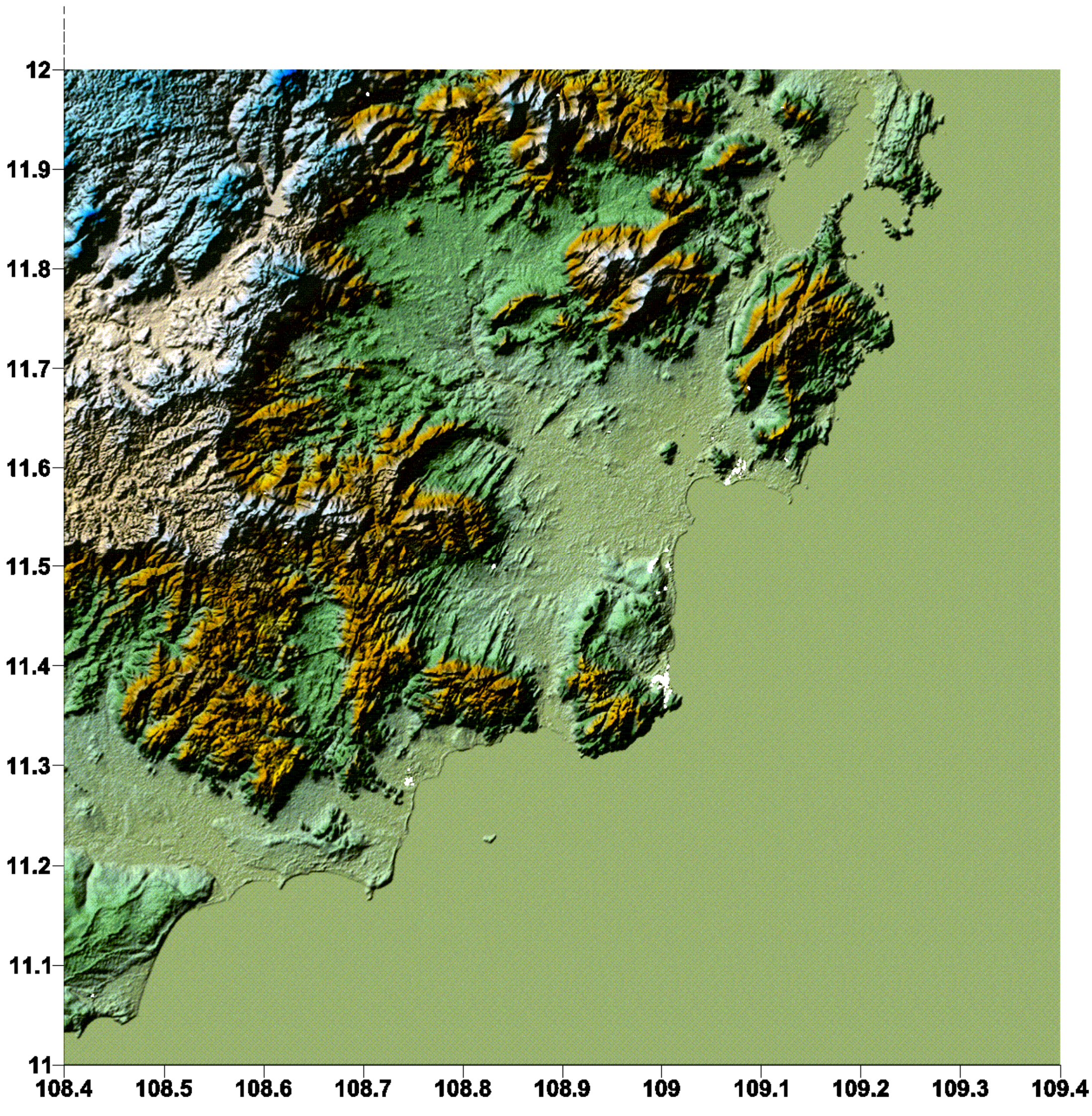

Figure 11: Digital topographic map of the Phouc Minh site based on NASA SRTM database.

Figure 12: Site of the met-mast installed at Ca Na during June 1998 – June 1999, indicated by the foundation. (Photo: RISO)

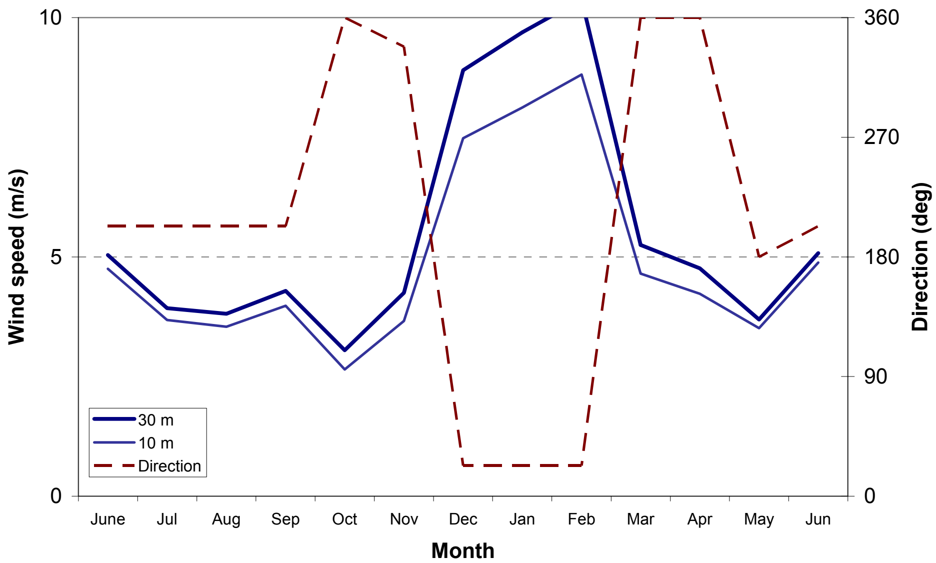

Figure 13: Monthly average wind data June 1998 – June 1999 from the Ca Na met-mast. (Data source: Elsamprojekt)

The wind conditions at the Phouc Minh site have been measured by PECC 3 by a 60 m met-mast (Figure 14).

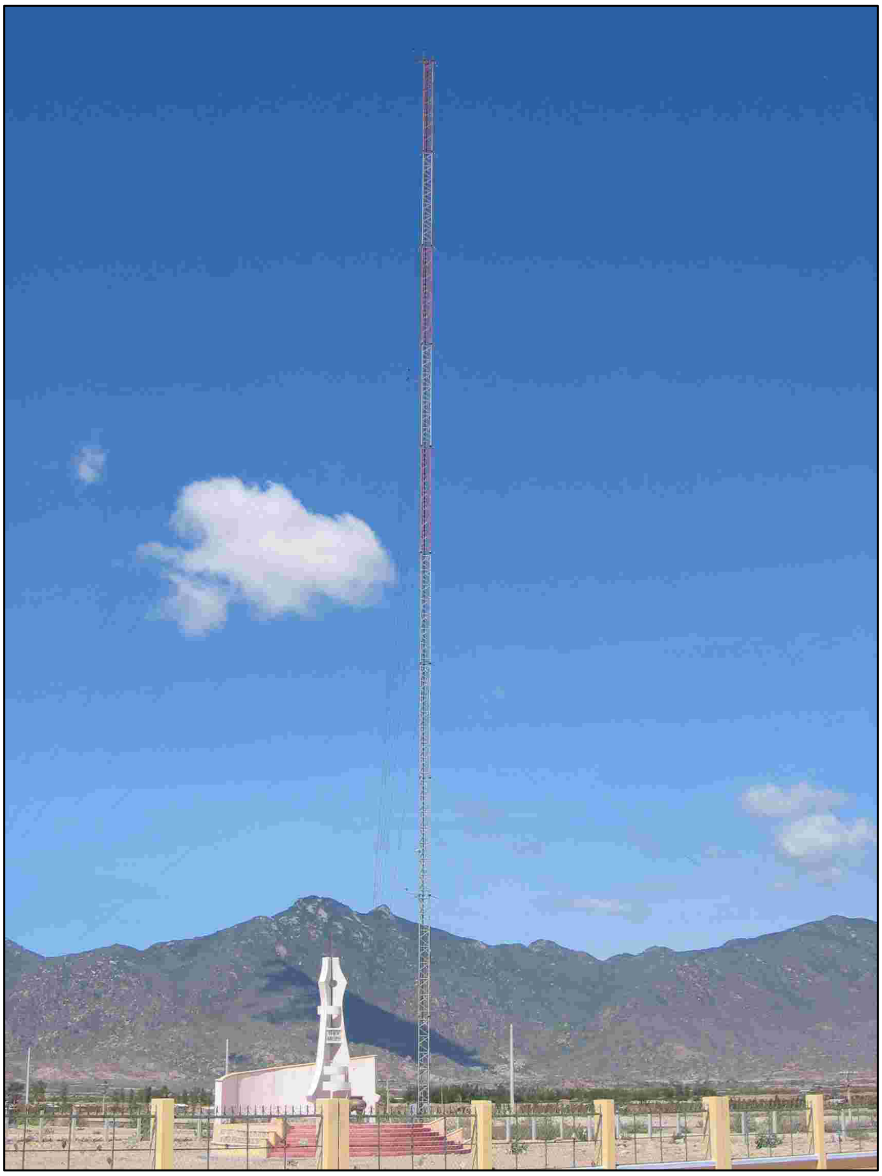

Figure 14: The PECC 3 met-mast at the Phouc Minh site. (Photo: RISO)

3.4.1 Climate and other physical conditions for design

Climate: Average annual temperature is 27.7oC (22.4oC - 35oC), humidity of 77%, number of sunshine hours is about 2700 hours/year. Average annual rainfall is 1322 mm. Two main wind directions in year are North – east and south-east.

Topography: The site proposed for project is located in the valley. In the east of the valley there is Da Bac mountain with crest of 643 m, steep slope, about 20km long running from sea towards North-South direction. In the west of the valley there are Da Giang, Gio mountains with crest of 897 m, less steep slope. These two mountains connected with the other mountains form high area by the sea, with dimensions of about 12 □15km.

The Valley is even and flat zone, laid in the North-South direction, with width of about 3km. This is a blank land area not affecting production and residence of people in the area. Besides this is a salt production field without trees and house higher than 10m.

Geological features: The surface of the selected site is sandy. At the deep of 2 – 4m there is soil – rock layer.

To be under eroded influence by sea salt and sand bank.

The site is easily accessible by Highway A1.

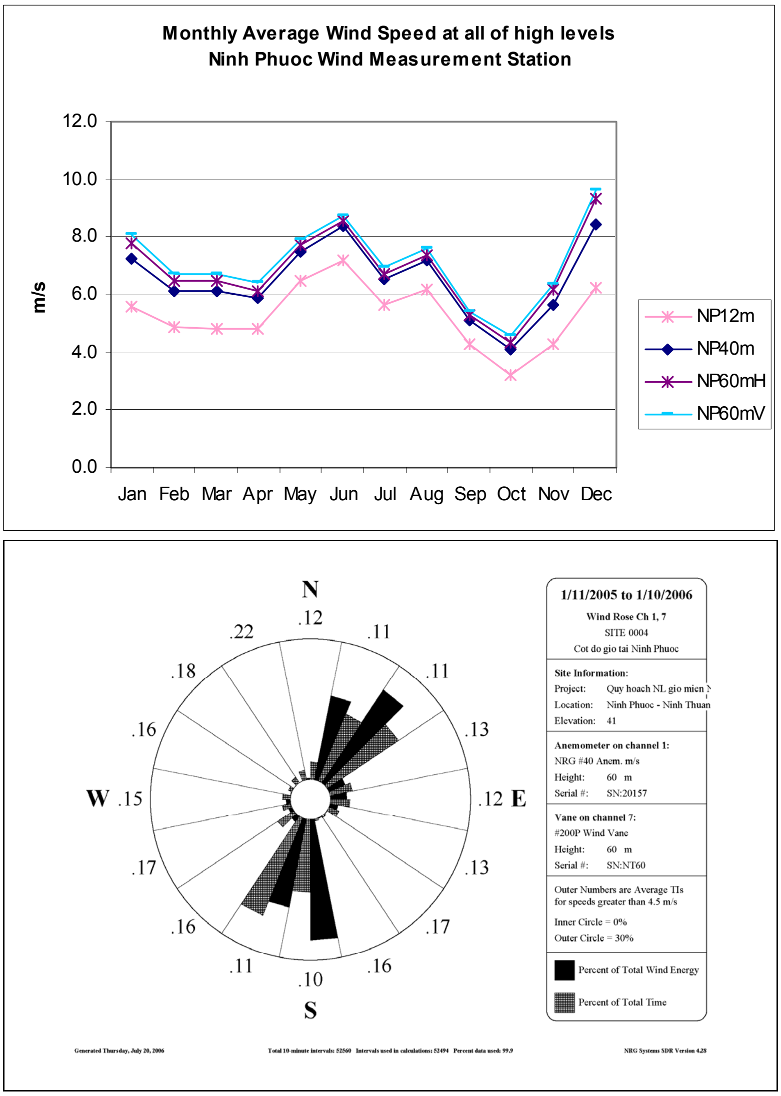

Figure 15: Statistics for the wind data for 2005 from the PECC3 met-mast at the Phuoc Minh site. (Source: PECC3)

3.5 Wind farm

In Figure 16 the lay-out of a 100 MW wind farm is illustrated – 50 wind turbine units of each 2 MW in 5 rows with 10 units each. The distances between the units in a row are 250 m (3 × rotor diameter), and the distances between the rows are 1000 m (12 × rotor diameter).

The annual production for a 2 MW Vestas V80 with 67 m hub-height (including 10 % wind farm wake losses) is estimated by PECC3 to 5.3 GWh. Wind turbine capacity factors of 30 % to 38 % for various wind turbines have been indicated for the Phuoc Minh site.

The wind farm investment for a large-scale inland wind farm at an easily accessible site like the Phuoc Minh is by the Project partners estimated at USD 1-1.5 mill per MW, or USD 50-75 mill for a 50 MW wind farm.

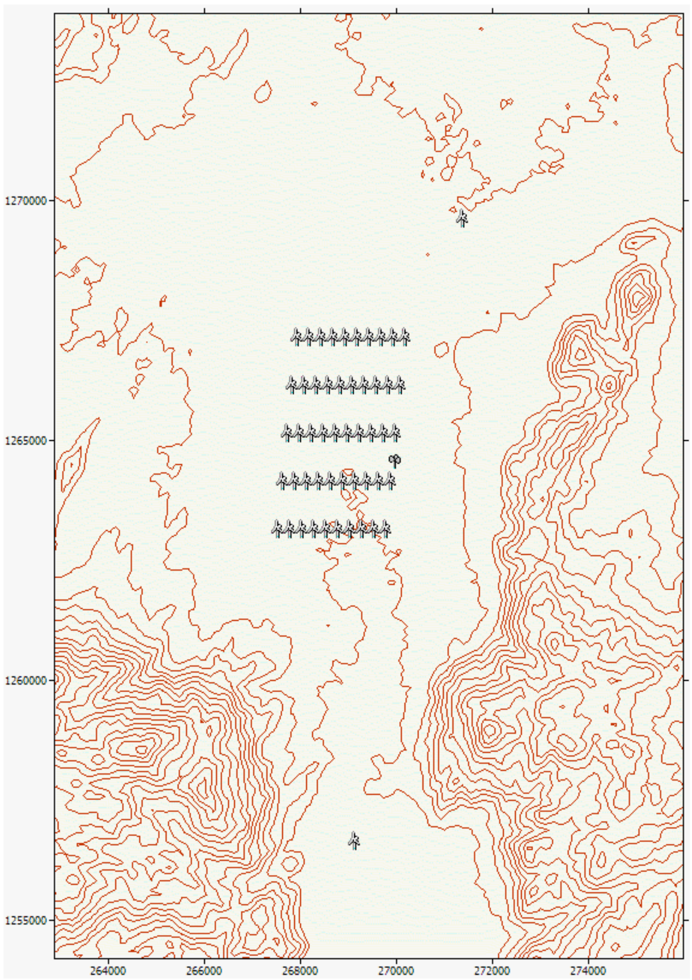

Figure 16: WAsP map of the Phouc Minh site with a wind farm, the Ca Na met-mast site indicated at the bottom, the PECC 3 met-mast in the middle and the power sub-station in the top (shown as a small wind turbine).

4 Tuy Phong

IE has installed a 60 m met-mast at the potential wind farm site Tuy Phong, 30 km south-west of the Phuoc Minh site. One full year of detailed wind data have been provided for the Project.

Site Description

Project area is located in Bình Thạnh commune, Tuy Phong district, Binh Thuan province (25 km far from Phuoc Minh Site), within following coordinates:

North latitudes: 108°40’30’’ – 108°42’

East longitudes: 11°12’15’’ – 11°12’50’’

This is cultivable land, but mainly land out of crop, sloped gently to the sea. This area is littoral sand dune terrain. This is state management land area and planed to afforest.

Project site is about 2 km far from the seaside. The site is 500 m from Highway 1A. North of the project site (at the other side of Highway 1A) there are low rocky mountains with 120 m

Figure 17: The Tuy Phong site just south of the Highway 1A and approximately 2 km from the sea, indicated at a satellite image map. (Source: GoogleEarth)

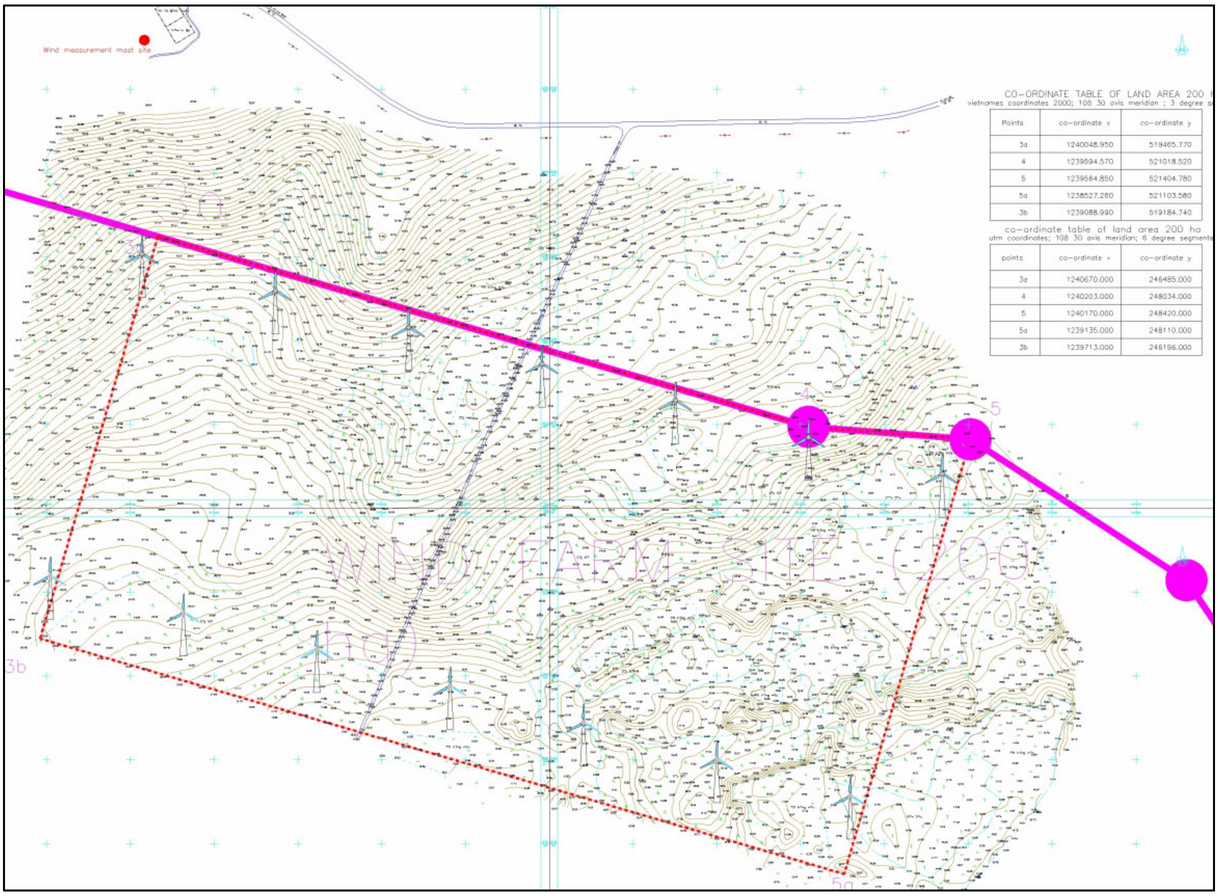

Figure 18: Proposed layout of a wind farm at the Tuy Phong site. (Source: IE)

height.

There is 110 kV power line parallel with Highway 1A and distance between 110 kV line and project site is about 1 km. Project site is about 25 km far from the Phuoc Minh site (Ninh Thuan).

Project area is located far from residential quarter. According to the economic development of Tuy Phong district up to 2010 (by Direction of Society), there are no new building projects in this project area.

Project size

Project area: 200 ha

Expected capacity: 34 MW (??) with 14 wind turbine of 2 MW will be installed.

co–ordinate table of land area 200 ha
utm coordinates; 108 30 axis meridian; 6 degree segments

points	co–ordinate x	co–ordinate y
3a	1240670.000	246485.000
4	1240203.000	248034.000
5	1240170.000	248420.000
5a	1239135.000	248110.000
3b	1239713.000	246196.000

Table 13: UTM coordinates for the wind farm indicated in Figure 18. (Source: IE)

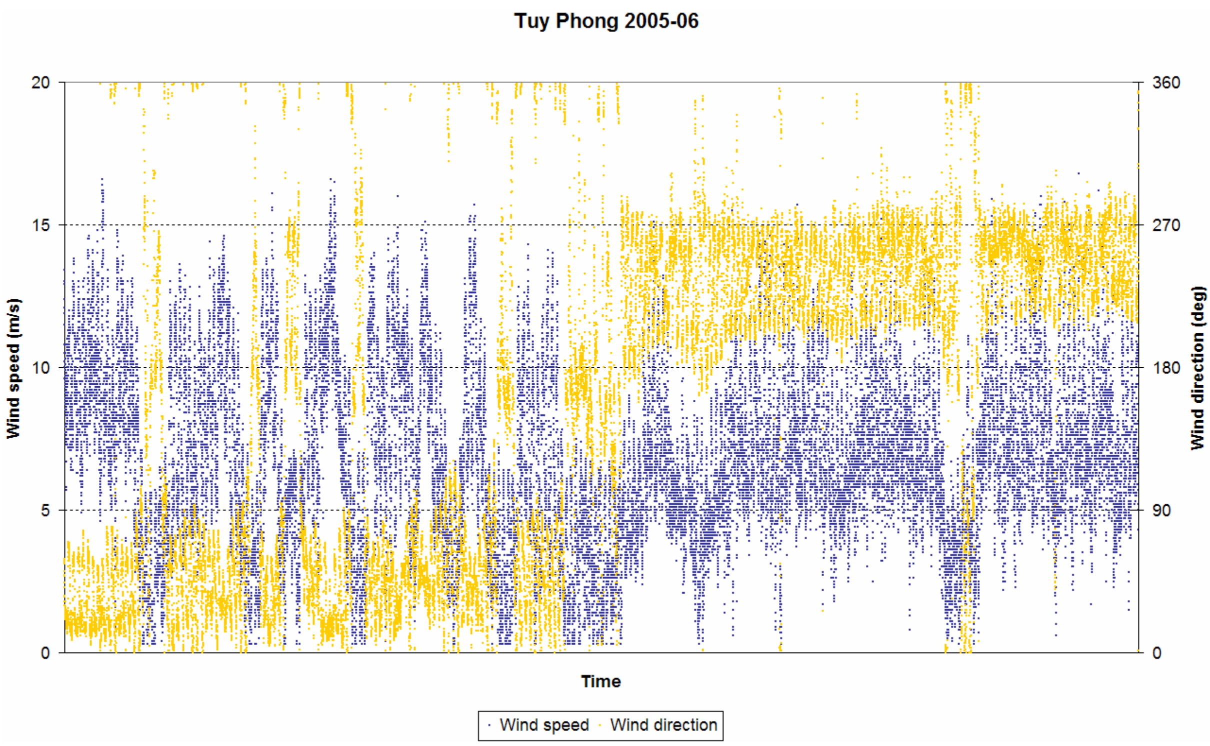

Figure 19: Time series plot of one year (Jan 2005 – Jan 2006) of wind speed and wind direction at 60 m height agl from the met-mast at Tuy Phong. The data indicate a shift of the wind direction in the middle of the year – like also indicated in Figure 13. (Data source: IE)

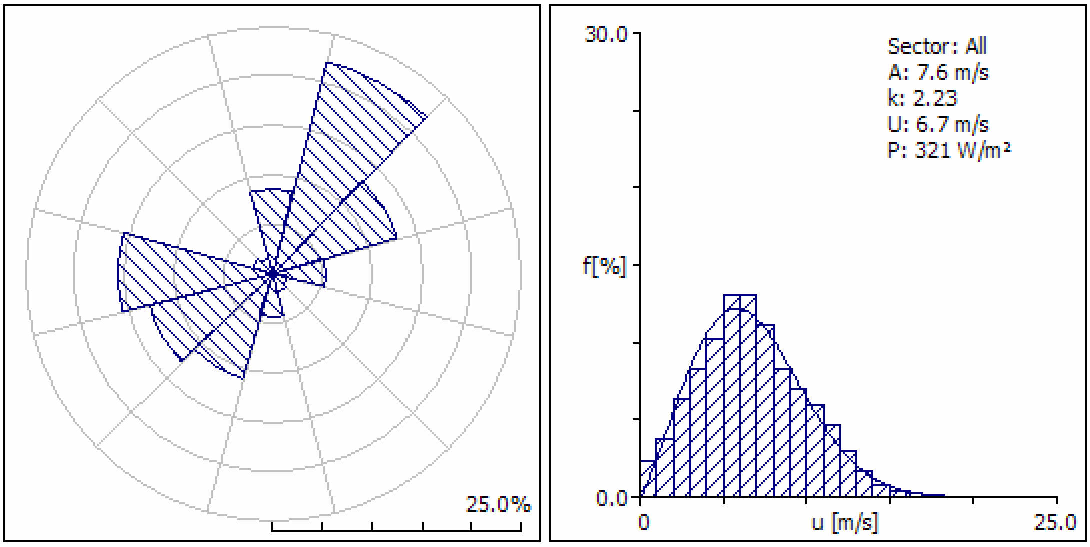

Figure 20: Wind direction and wind speed statistics for one year wind data (Jan 2005 – Jan 2006) at 60 m height agl from the met-mast at Tuy Phong. (Data source: IE)

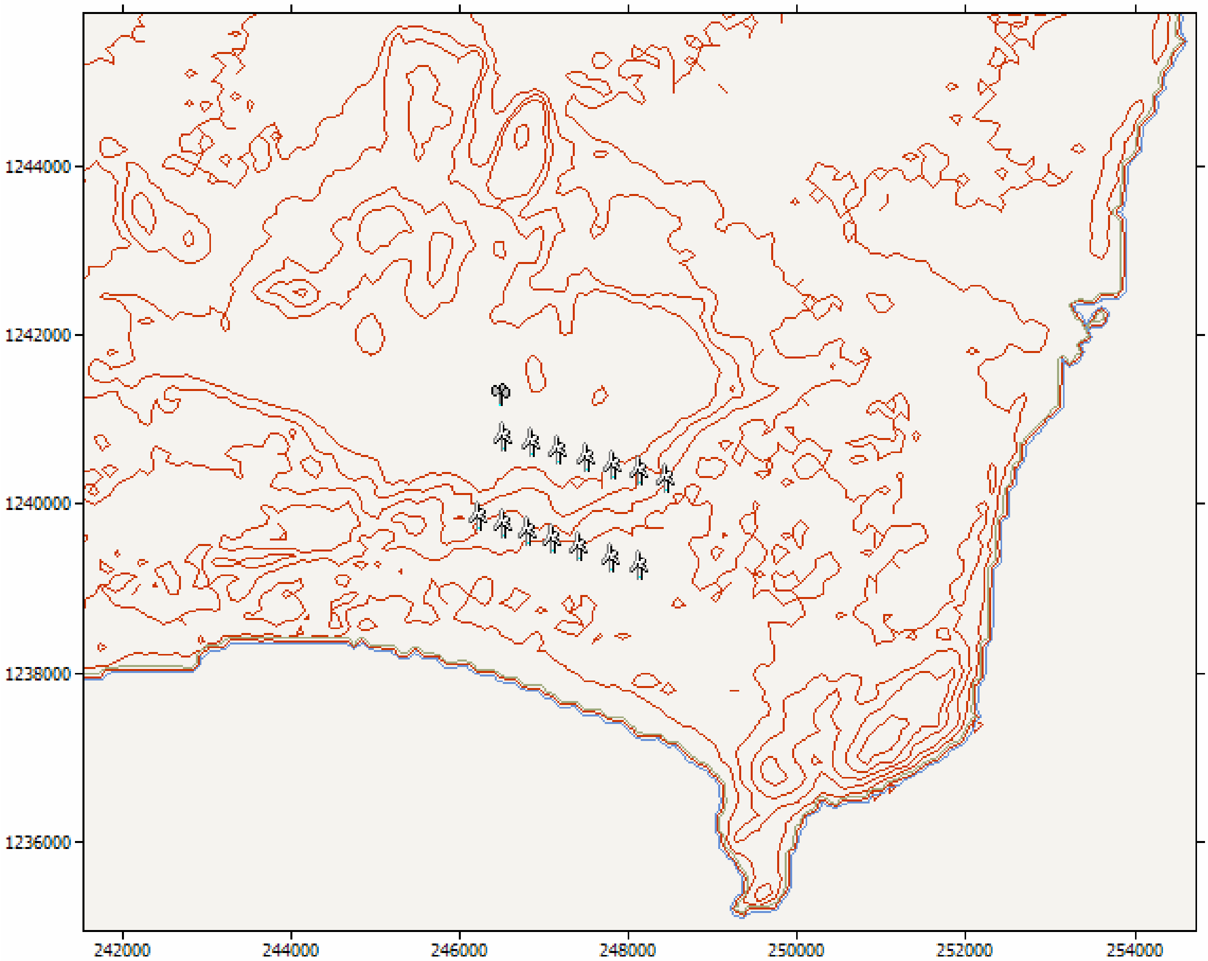

Figure 21: WAsP map of the Tuy Phong met-mast and proposed wind farm with 14 wind turbine units.

Site ID	Site x [m]	Site y [m]	Elev. [m]	Ht [m]	U [m/s]	Gross [GWh]	Net. [GWh]	Loss [%]
Turbine site 1	246485.0	1240670.0	56.0	67.0	6.99	5.257	5.142	2.2
Turbine site 2	246824.4	1240585.0	53.0	67.0	7.05	5.361	5.095	4.96
Turbine site 3	247151.0	1240502.0	53.0	67.0	7.09	5.424	5.117	5.66
Turbine site 4	247477.6	1240412.0	51.0	67.0	7.11	5.451	5.117	6.12
Turbine site 5	247797.3	1240328.0	47.0	67.0	7.08	5.416	5.067	6.43
Turbine site 6	248103.0	1240248.0	39.0	67.0	7.07	5.394	5.044	6.47
Turbine site 7	248420.0	1240170.0	28.0	67.0	7.02	5.324	5.048	5.19
Turbine site 8	246196.0	1239713.0	30.0	67.0	6.95	5.202	4.923	5.37
Turbine site 9	246494.3	1239633.0	25.0	67.0	6.94	5.187	4.778	7.88
Turbine site 10	246782.7	1239539.0	20.0	67.0	6.86	5.063	4.676	7.65
Turbine site 11	247081.5	1239446.0	19.0	67.0	6.91	5.155	4.778	7.31
Turbine site 12	247383.8	1239348.0	18.0	67.0	6.97	5.247	4.922	6.2
Turbine site 13	247762.5	1239230.0	17.0	67.0	7.03	5.343	5.077	4.98
Turbine site 14	248110.0	1239135.0	17.0	67.0	7.05	5.370	5.189	3.35

Table 14: Estimated annual generation calculated by WAsP for each of the wind turbines of the wind farm indicated in Figure 21 based on the one year wind data indicated in Figure 19. Turbine site 1 to 7 in the northern row from W to E, and Turbine site 8 to 14 in the southern row from W to E.

Tuy Phong 28 MW wind farm (14 × 2 MW) estimated annual production: 70 GWh – corresponding to 2.5 GWh per MW installed capacity or a capacity load factor of 28%.

5 Ly Son Case - 1 MW island system

Wind resource

Based on data of system of meteorological stations uniformed in terms of observation medium, observation time calculation methods and self-registering devices, Meteorological Institute carried out calculation of average annual and monthly wind speeds for the whole network of meteorological stations and average hourly wind speeds for those stations which have self - recording devices.

According to data measured in Ly Son hydro-meteorological station over 13 year period from 1985 to 1997 at height of 12 m above ground surface, monthly and yearly average wind speeds are as follows:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
V_{ave} (m/s)	4.94	4.86	5	4.73	4.53	4.74	4.64	4.8	4.75	5.39	6.54	6.33	5.1

The data in the above table indicate main wind directions in months. The north - east wind direction accounts for 40 - 45%, from September to February. Southeast wind direction accounts for 52 - 68% from March to August. The northwest wind direction is also important,

Figure 22: Location of the Ly Son Island in the Chinese Sea 30 km from the mainland.

accounting for 19 - 27%, from October to April. Therefore, when selecting site, the attention should be paid so that after installation, wind turbines can catch wind from all above three directions.

Climate and other physical conditions for design

Climate: The climate is tropical with monsoon wind. The rainy season lasts from September to February with rainfall accounting for 75% of whole year rainfall. Dry season is from March to August subject to south-east wind. Average annual temperature is 26.4°C. Average annual rainfall is 2000 mm.

Topography: In general, the topography is even with elevation from 20 to 30m over the sea surface (there are no big rivers or streams on the island. There is only small stream which flows in rainy season). Most lands have slope less than 8o, suitable for agricultural production and residential settlement.

Geological features: An even and flat zone of middle Island is foundation of clay and basalt soil with relative large thin but spongy, under layer is foundation of weathered sandstone with big thin. Underground water appears on deep of 10 – 15m. Hill near mountain zone is foundation of basalt soil.

To be under eroded influence by sea salt. There are sand bank on Island.

5.1 National and Local Development Planning

Energy Policy

Development of renewable energy must be based on the objectives of economy, society, environment and living standards in each ecological area. The Government can provide financial assistance for renewable energy projects based on average income of rural and mountainous households. 100% tax exemption for import of renewable energy equipment and technologies. Efforts should be focused on study and application of renewable energy technologies in areas which are impossibly connected to national power grid due to difficult topographical conditions or too expensive investment. Wind energy should be used in island and mountainous areas where are impossibly connected to the national power grid and encouraging use of wind power generation.

Development target

The Island district will mobilize all resources for promotion of sea economic development, integrating expansion of fishery services, tourist services, commerce, and stabilization of economic development in order to ensure high economic growth rate, eradication of hungry households and alleviation of poor households, changing rural aspects and maintaining national defence security.

Particular objectives:

- GDP growth rate in 2001-2005 is 7 - 8% / year, in 2006-2010 is 10% / year.

- Average income capita per year will be 403 US$ in 2005; 540 US$ in 2010.

- Natural population growth rate: 1.6% in 2005 and 1.4% in 2010.

- Annual increase of ship quantity is 10.

- By the beginning of 2005 there will be a clean water system for living and production.
- By 2005, there will be no hungry households and 70% of poor houses will be reduced.

Indicator	Unit	2000	2005	2010
I Growth rate				
Population	%/year		1.6	1.4
GDP	%/year	7.6	7-8	10
GDP Industry Craft	%/year	15.8	24.0	14
GDP Agriculture	%/year	10.3	8.4	4
GDP Sea economy	%/year	8.6	11.1	11
GDP service, commerce	%/year	7.4	8.4	9
II Indicator				
Natural land area	ha	997	997	997
Population	people	19500	21110	22630
GDP	mil.VND	121601	200714	294900
Average in come	US$	192	403	540
III Structure				
Industry, crafts	%	2.2	4.0	5.0
Agriculture	%	12.8	11.6	8.6
Sea economy	%	57.9	60.0	63.0
Services, commerce	%	27.1	24.4	23.4

Table 15: Targets of Sustainable Growth Rates of Ly Son Island District

Population

Population: total population of the district as of June 2003 was 19,860 people living in 4,012 households.

Infrastructure and physical planning

Ly Son district is an island district which was separated from Binh Son district in 1993. Ly Son island district has also name of Cu Lao Re existing from end of XVI century and Name of Ly Son began from 1998. This is one of 13 districts, towns of Quang Ngai province.

Location: Ly Son Island district is located in northwest of Quang Ngai province with latitude coordinates from 15°32' to 15°58', longitude coordinates from 109°5' to 109°14' east. It lays on the way to Eastern Sea through Central region via Dung Quat, 25 miles from the Dung Quat industrial zone in the west and 18 miles from Sa Ky port of Son Tinh district in the south- west.

Area: Ly Son island district has natural land area of 997 ha including two islands (big and small) namely Ly Vinh and Ly Hai communes.

Natural resources: The land is surrounded by Sea; therefore the district has favorable conditions for raising aquatic products. Total reserve of seafood of Quang Ngai Sea is about 80000 tons of which exploitable potential are of 33000 tons/year. Ly Son island district alone can exploit 6500 tons/year.

Traffic: Include

- Road traffic: 23 km (big Island: 20.6 km; small Island: 2.5 km), 12 km spread asphalted road, remaining pathway and stone paved road.

- Sea traffic: Now, 3 main line: Ly Son – Sa Ky (18 sea mile); Ly Son – Phu Tho (25 sea mile); Ly Son – Sa Can (25 sea mile). Ly Son island district has 3 ports, but main used is Ly Vinh port with anchorage 400 tones.

Electricity demand and load forecast

Sector	**2005 (kW)**	**2010 (kW)**
Industry - construction	23	380
Agriculture - forestry - fishery	60	60
Services - commerce	35	60
Lighting and management	973	1972
Other demand	82	140
Pmax	900	1780

Table 16: Ly Son power demand up to 2005 and 2010. (Source: IE)

Sector	**2005**		**2010**		**Annual growth rate (%)**	
	A (MWh)	%	A (MWh)	%	2000-2005	2006-2010
Industry - construction	405	23.8	760	22		13.4
Agriculture - forestry - fishery	60	3.5	60	1.7		0
Services - commerce	35	2.1	72	2		15
Lighting and management	1080	63.4	2366	68	33.3	17
Other demand	123	7.2	210	6.1	52.0	11.3
Total sales	1703	100	3468	100	44.4	15.3
Loss + owned use	277	14	428	11		
Electricity production	1980		3896		41.5	14.5

Table 17: Ly Son electricity demand up to 2005 and 2010. (Source: IE)

Therefore, average electricity consumption per capita for Ly Son district is 78 kWh in 2005 and 149.5 kWh in 2010. Due to the low start point, although electricity consumption growth rate in coming years is rather high (44.3% in the period 2001-2005 and 15.3% in the period 2006-2010), but electricity consumption per capita is still low.

5.2 Electrical grid interconnection

Power Supply

At present, Power Supply to meet living demand of people on Ly Son district Island includes two Diesel Stations:

- The first Ly Son Diesel Station (five generators): 1 x 304 kW- Wilson; 2 x 366 kW-IVECO; 2 x 200 kW-EGM has been constructed on Ly Hai in 1999. All of these generators are very old, so they must be repaired and maintenance too much and it will be stopped completely when the second station will be operated.

- The second Diesel Station (two generators): 2 x 780 kW- SKODA has been constructing since June, 2005 in stead of the first station. They have been connecting to 22 kV grid system through step-up transformer 0.4/22 kV, supply 11 transformers 22/0.4 kV with capacities from 100 kVA to 250 kVA each. Operation time of diesel generators is 5 hours per day.

- Small island Diesel Station 1 x 15 kVA, has been connecting to 0.4 kV grid, has been constructing since 2000, electricity supply to households on small island.

Besides, there are some Diesel Stations of Post Station; Radio Broadcasting Station; People's District Committee; Health District Centre; Lighthouse Station, to generate electricity alone or backup.

Actual state of Power sources on Ly Son Island

Power sources	**Location**	**Capacity (KVA)**	**Year of Operating**	**Note**
Ly Son Diesel	An Hai	1 x 380 2x 457 2x 250 2 x 975	1999 2001 2001 end of 2005	22kV 22 kV 22 kV 22 kV
Small island Diesel	Small island	1 x 15	2000	0.4kV
Ly Son Post Station	Post Station	2 x 8	1995	backup
Radio Broadcasting Station	Radio Broadcasting Station	1 x 5	Before 1995	backup
People's District Committee	People's District Committee	1 x 3	Before 1995	backup
Health District Centre	Health District Centre	1 x 5	1996	backup
Lighthouse Station	Lighthouse Station	1 x 5	1994	Independent
Radar 505	Radar 505	40	Before 1995	Independent
At long range Radar	At long range Radar	4 x 40	1998	Independent
Total		**1 256**		

Grid system

- Medium Voltage lines 22 kV with total length are 3815 m, conductor M50.
- Low voltage lines 0.4 kV, with total length 9.44 km.

Lines	**Conductor**	**Length (m)**	**Note**
Medium Voltage lines 22 kV		**3185**	
Ly Son Diesel - An Hai - An Vinh	M50	3185	
Low voltage lines 0.4 kV		9438	
- Ly Son Diesel - An Hai 5	CV-50	1100	
- An Hai 1	CV-50	720	
- An Hai 4	CV-50	500	
- An Vinh 5	CV-50	670	
- An Vinh 2	CV-50	812	
- An Vinh 6	CV-50	400	
- An Vinh 1	CV-50	1520	
- An Vinh 3	CV-50	472	
- An Vinh 4	CV-50	280	
- Ly Son Diesel - An Hai 2	CV-50	992	
- An Hai 3	CV-50	972	
- Small island	CV-50	1000	

- Transformers

Stations	**Capacity (KVA)**	**Voltage (kV)**	**Pmax (kW)**	**Note**
Ly Son Step-up Transformer	1770	0.4/22	700	
Step-down Transformer	1910	22/0.4	1244	
- An Hai 1	250	22/0.4	220	surcharge load 10%
- An Hai 2	160	22/0.4	102	
- An Hai 3	250	22/0.4	160	
- An Hai 4	100	22/0.4	64	
- An Hai 5	100	22/0.4	64	
- An Vinh 1	250	22/0.4	160	
- An Vinh 2	160	22/0.4	90	
- An Vinh 3	160	22/0.4	102	
- An Vinh 4	160	22/0.4	90	
- An Vinh 5	160	22/0.4	102	
- An Vinh 6	160	22/0.4	90	

Figure 23: The diesel power plant at Ly Son. (Photo: RISO 2006)

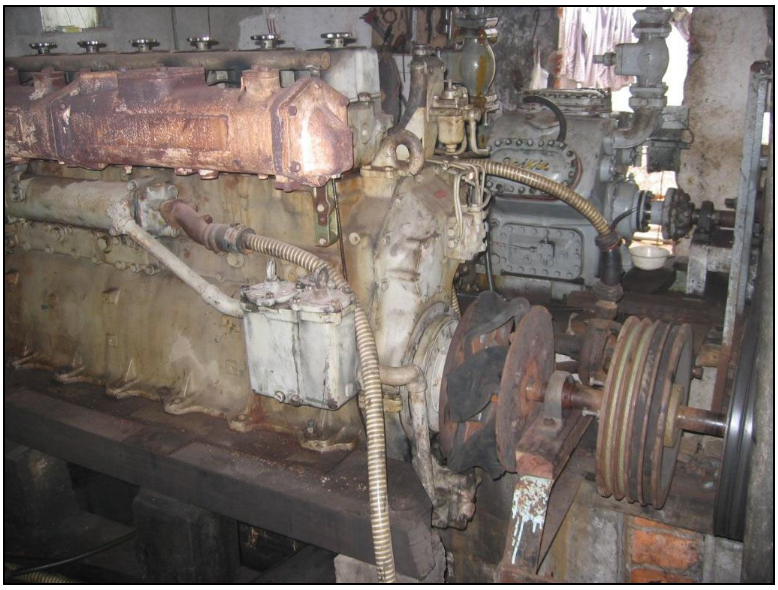

Figure 24: A diesel powered compressor for a private owned ice factory at Ly Son, visited by the project team. (Photo: RISO 2006)

Figure 25: Examples of electrical appliances in the private households at Ly Son. (Photo: RISO 2006)

5.3 Wind resources

IE is operating a met-station, installed in the beginning of 2006 at the middle of the island, a potential site for the installation of wind turbines. Shortly after the formal termination of the Project, one full year of wind data was collected and provided to the Project. The average wind speed at 60 m height level for 2006 was 5.9 m/s and the maximum wind speed recoded was 29 m/s. The one year wind data form the basis for the WAsP analysis of the estimated annual production for the wind turbines. The estimated annual production from the three 350 kW Suzlon wind turbines assumed in the power analysis is 1.8 GWh.

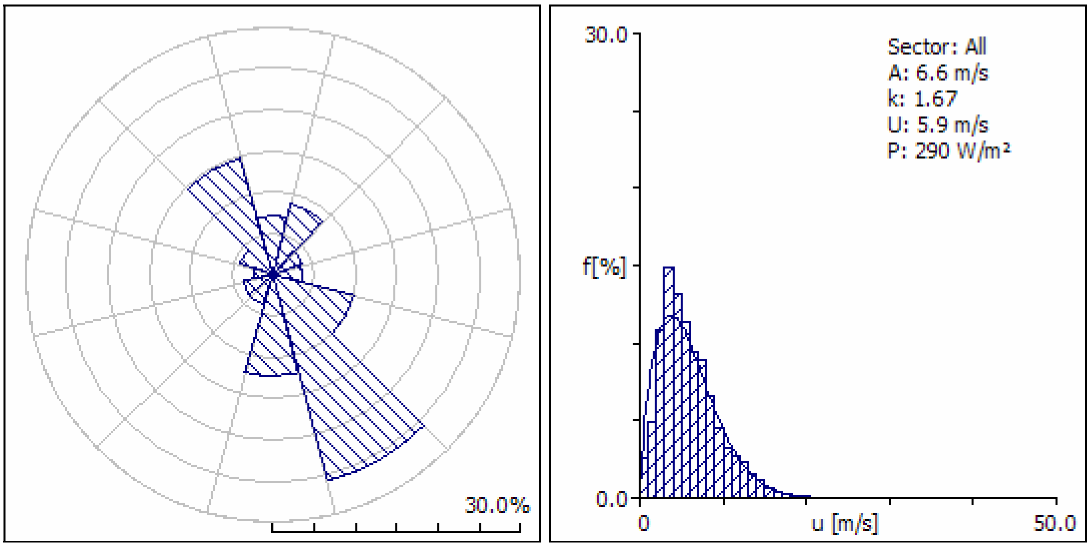

Figure 26: Wind statistics based on one full year of data (060123-060110) from the IE met-mast at Ly Son. (Data source: IE)

Figure 27: IE's met-station at Ly Son. (Photo: RISO 2006)

Figure 28: The 12 m met-mast at the Ly Son Met-Station that may provide long term wind reference. (Photo: RISO 2006)

Adequate long term reference wind data are available from the Ly Son Meteorological Station at the east point of the island. However, only 2005 data were made available for the Project

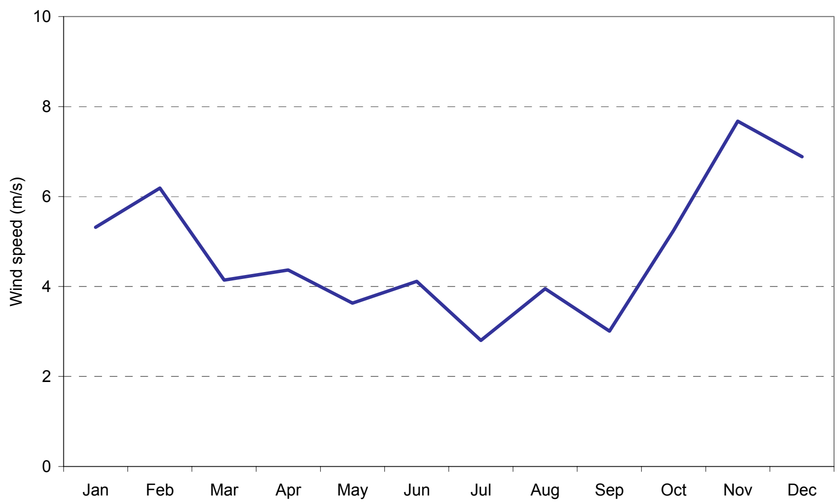

Figure 29: Monthly average wind speed statistics of data at 12 m height level from the Ly Son Met Station for 2005. (Source: IE)

and we have no information if the data from the IE met-mast from 2006 are representative for the long term wind resources at Ly Son.

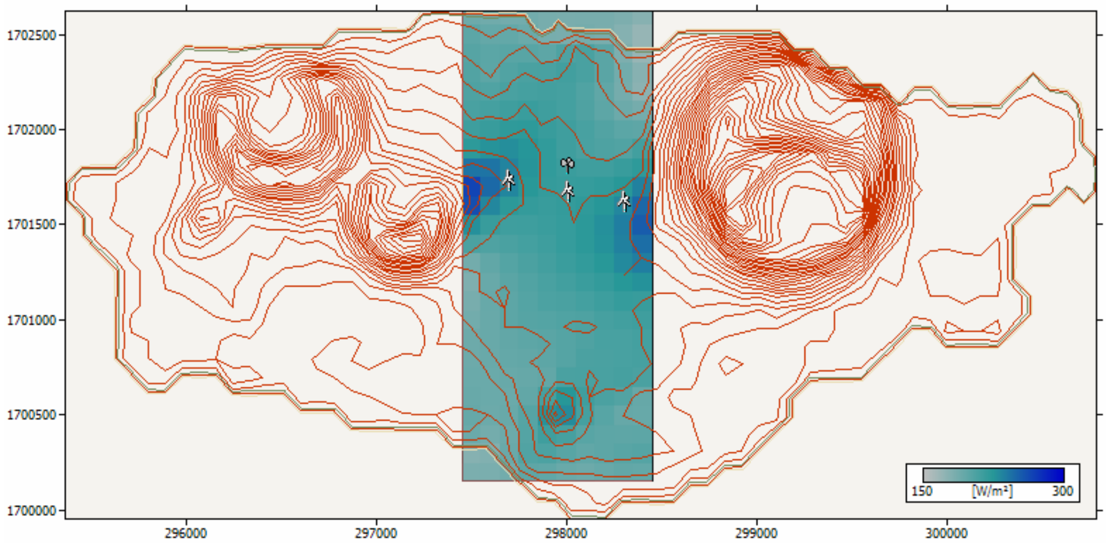

Figure 30: WAsP map of Ly Son Island indicating the IE met-mast site and three proposed wind turbine sites. In addition a WAsP mapping of the expected wind resources (in W/m^2 at 60 m height agl) is shown.

5.3.1 Wind-diesel power system

The value of the wind power – in terms of expected reduced diesel fuel consumption relative to pure diesel operation for a given supply – has been estimated using the IPSYS[1] power system analysis tool for various combined wind + diesel power supply system scenarios for Ly Son, based on the information made available for the project.

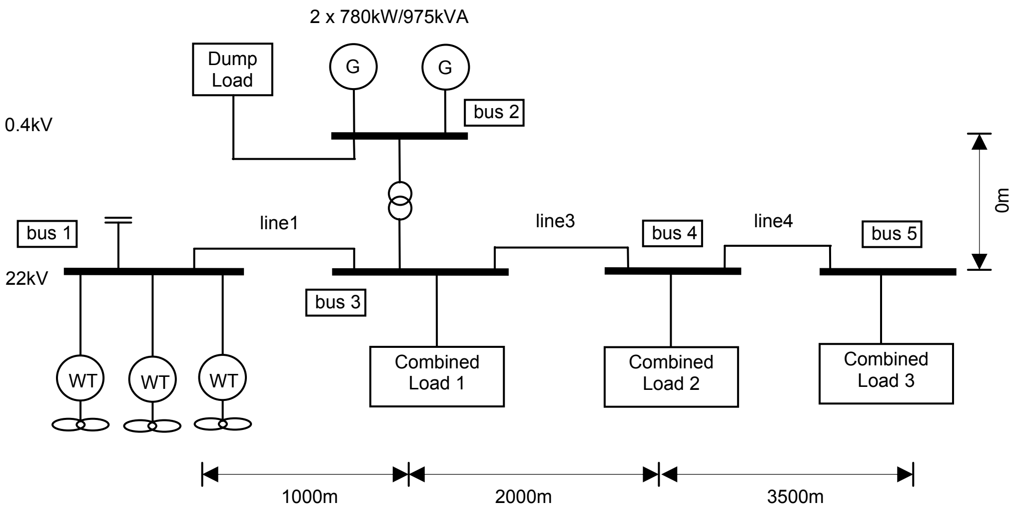

Figure 31: Single line diagram of the power supply system at Ly Son Island, inclusive three wind turbine units. (Source: RISO)

[1] IPSYS is a time domain power system analysis tool developed by Risø National Laboratory.

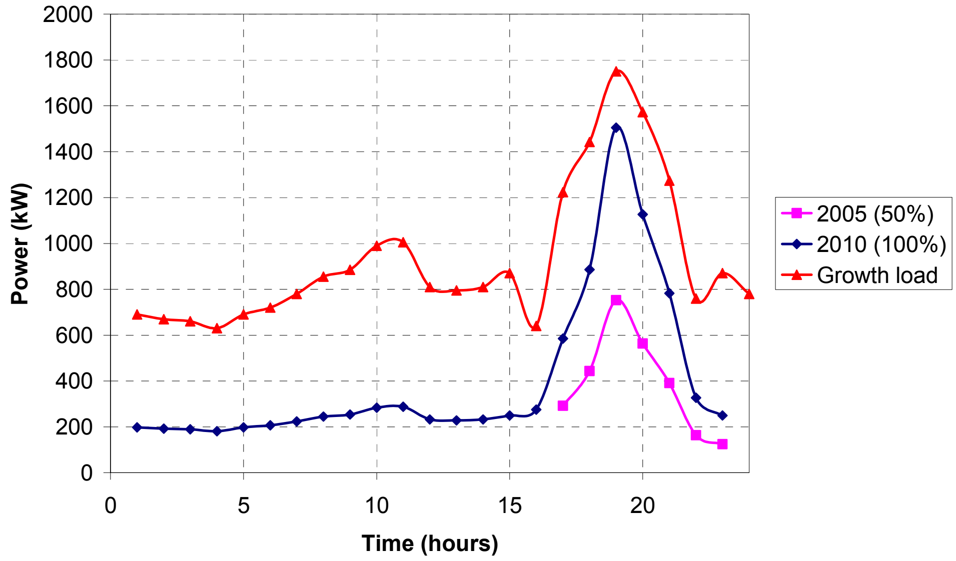

Figure 32: The expected 24 hours load profile for Ly Son Island over the day based on the information made available. (Source: RISO)

The obtained diesel fuel reduction is very sensitive to the minimum constantly diesel load accepted by the diesel engines. The highest fuel reduction is obtained when exchanging the existing old diesel generators with new diesel generators, designed for low load operation and with increased performance.

24 hours power supply and increased power consumption are assumed in the IPSYS analysis of the combined wind-diesel power supply system – see Figure 32.

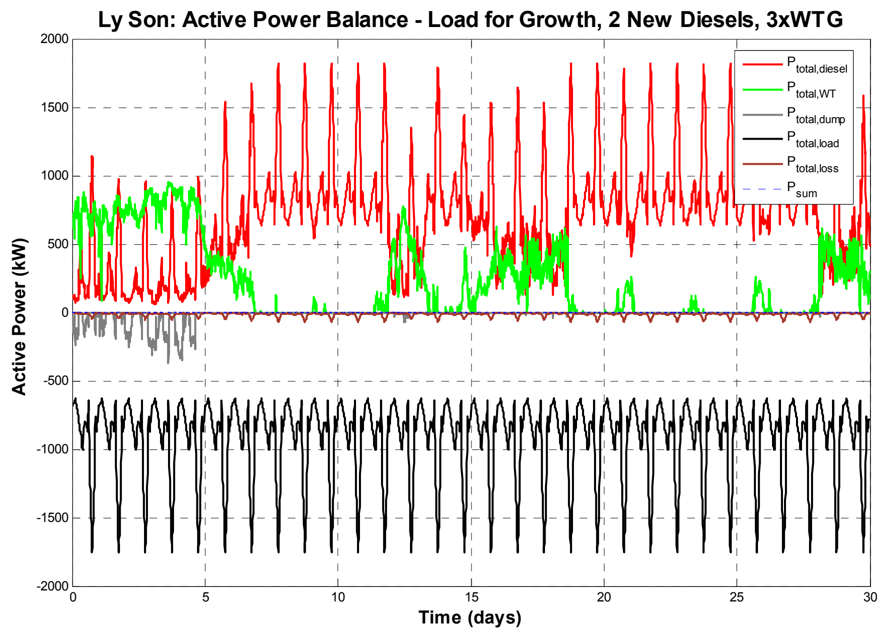

Figure 33: The results from one month IPSYS simulation of the combined wind + diesel power supply system at Ly Son with the load profile from Figure 32. (RISO)

Power system scenario

1: Existing diesel generators.

2: Existing diesel generators with 2x350 kW (2a) and 3x350 kW (2b) wind power respectively.

3: One additional new diesel generator and 3x350 kW wind power.

4: Two additional new diesel generators and 3x350 kW wind power.

The results of the IPSYS simulations for the various power system scenarios are indicated in Table 18.

Scenario	Diesels	WTGs	Fuel used	Wind Energy Share	Wind Energy Usage	Dump Load Share
1	2 x 680kW Skoda 1 x 360 kW IVECO	0	100%	0%	0%	0%
2a	2 x 680kW Skoda 1 x 360 kW IVECO	2 x 350 kW	83%	16%	99%	0.2%
2b	2 x 680kW Skoda 1 x 360 kW IVECO	3 x 350 kW	79%	24%	84%	4%
3	1 x 680kW Skoda 1 x 680kW (new) 1 x 360 kW IVECO	3 x 350 kW	72%	24%	87%	3%
4	2 x 680kW (new) 1 x 360 kW IVECO	3 x 350 kW	67%	25%	94%	1%

Table 18: Results from IPSYS simulations for the various scenarios for the Ly Son power supply system. Reference is the existing diesel generation. (RISO)

In scenario 4 the value of the investment of two new diesel generators and the three wind turbines is a reduction of the diesel fuel consumption to 67%. The present specific diesel fuel consumption is 0.25 kg/kWh and with an estimated annual power consumption of 5 GWh the diesel fuel savings correspond to 400 ton diesel fuel annually.

6 Summary

The feasibility of wind power has been analysed for two selected cases in Vietnam – the Phuoc Minh mainland case with large-scale grid connected wind power and the Ly Son Island with combined wind-diesel operation. Data for the feasibility analyses have been collected as part of the Project.

6.1 Main findings

Key figures from the technical feasibility analyses

	Vietnam		Philippines	
	Phouc Minh	Ly Son	Sta. Ana	Dinagat
	Grid	Island	Grid	Island
Location From date To date Height Mean speed Mean power Max speed	11.5°N 109.0°E Jan 2006 Dec 2006 60 m 7 m/s 400 W/m^2 	15.38°N 109.12°E 060123 070110 60 m 6.0 m/s 290 W/m^2 29 m/s	18.45°N 122.13°E 050912 060918 27 m 5.0 m/s 132 W/m^2 18 m/s	10.05°N 125.58°E 050813 060926 30 m 5.1 m/s 210 W/m^2 21 m/s
Capacity Units Production Units Production Investment	50 MW 2MW V80/67m 130 GWh/y 50 MW: 50-75 M$	1050 kW S33-60 350kW 1.8 GWh/y 2 M$	30 MW 2 MW V66 / 67 m 60 GWh/y 2 MW V80 / 67 m 80 GWh/y 30 M$	180 kW 286 MWh/y 0.5 M$
Step-up trafo Power line Investment			69 kV / 30 MVA 12 km / 69 kV	13.2 kV
Updated	2007-01-22	2007-01-22	2007-01-30	2007-01-22

6.2 Conclusions

For both selected cases in Vietnam there are good technical potentials for utilisation of wind power.

A large-scale wind farm can be erected at the Phuoc Minh site and connected to the existing 110 kV power transmission line crossing the site. The site is well located near the grid and easily accessible. The load factors of the wind turbines are estimated to be at least 30 % - usually economically feasible for land based wind farms.

Upon replacement of the existing old diesel-generators at Ly Son Island with new diesel generators designed for low load operation, 24 hours power supply and limited installed wind power capacity, the value of the wind power – in terms of reduced diesel fuel relative to pure diesel operation – is estimated at 400 ton fuel annually per MW of wind power capacity installed. The investment cost of wind power capacity at Ly Son is estimated at USD 2 mill per MW.

6.3 Recommendations

Before the investment of wind power at Phuoc Minh it is recommended:

- to investigate the potential and the value of coordinated operation of the wind power and the hydro power;
- to establish an adequate long term wind reference for the Phuoc Minh + Tuy Phong area.

Before the investment of wind power at Ly Son it is recommended:

- to implement another financial model for the operation of the power supply system at Ly Son that makes it attractive for the operator to supply the needs;
- to install reliable wind turbines;
- to establish a simple and robust control of the combined wind-diesel power supply system.

Annexes

List of Project Deliverable Reports

#	Task	Title	Country
1	1.6	Extreme wind analysis	The Region
2	4.2	Design of WTG in Typhoon area	The Region
3	3.4	GIS analysis	Philippines
4	1	Wind resource assessment report	Philippines
5	1	Wind resource assessment report	Vietnam
6	2.2	Overview of grid infrastructure	Philippines
7	2.2	Overview of grid infrastructure	Vietnam
8	2.2	Overview of grid infrastructure	Cambodia
9+10	2.3	Analysis of power quality and voltage stability	Philippines & Vietnam
11	3	Policy and market study	Philippines
12	3	Policy and market study	Vietnam
13	3	Policy and market study	Cambodia
14	4	Technical feasibility report	Philippines
15	4	Technical feasibility report	Vietnam
16	5	Economical feasibility report	Philippines
17	5	Economical feasibility report	Vietnam
18+19	6	CDM analysis	Philippines & Vietnam
20+21	7	Financial Framework	Philippines & Vietnam
22	8	Guideline report	Philippines & Vietnam
23	All	Mid-term status report	All 3
24-31	All WS	Workshop reports	All 3

Technical Feasibility Workshop – Hanoi July 2006

24 July	**Technical wind power feasibility analyses**		
9:00	Introduction	Tran Thanh Lien	IE
9:10	Welcome to the Workshop	EC Representative	EC Hanoi
9:15	Welcome to the Workshop	Nguyen Manh Hung	MoI
9:20	Opening of the Workshop	Pham Khanh Toan	IE
9:25	***Group Photo session***		
9:35	***Tea break***		
	Session 1:Technical wind power feasibility analyses	Chaired by: Pham Khanh Toan Per Norgaard	 IE Riso
9:55	Integration of wind power in Vietnam	Nguyen Manh Hung	MoI
10:20	Introduction to the workshop	Per Norgaard	Riso
10:45	Introduction to the Economic / Financial - CDM Workshops	Emmanuel Huard Bernt Frydenberg	IED Mercapto
11:10	Elements in the technical feasibility analysis	Ana Candelaria	PNOC-EDC
11:35	Cost and value of wind power	Per Norgaard	Riso
12:00	***Lunch***		
	Ca Na case – grid connected, Vietnam		
	Land availability and access - Vietnam	Nguyen Tien Long	IE
	Wind resource and design wind assessment in Vietnam	Nguyen Quoc Khanh	IE
	Wind resource and design wind assessment - Ca Na (Ninh Phước).	Mr. Hung	PEEC3
	Grid connected Ca Na wind power plant	Nguyen Anh Tuan	IE
	Discussion		
15:10	***Tea Break***		
	Ly Son case – island system, Vietnam		
	Introduction to the Ly Son case	Per Norgaard	Riso
	Potential and value of wind power in island systems – Vietnam. Load and Wind statistics - Ly Son Island case	Nguyen Tien Long	IE
	Power system operation – Ly Son case	Tom Cronin	Riso
	Discussion		
16:45	Summary of Day 1	Per Norgaard	Riso
17:00	***Closing Day 1***	***Pham Khanh Toan***	***IE***
18:30	***Official Workshop Dinner***		

25 July	**Session 2: Grid connected wind power**	Chaired by: Tran Thanh Lien Per Norgaard	 IE Riso
8:30	Introduction to the day	Per Norgaard	Riso
	Land availability and access – Philippines	Ana Candelaria	PNOC-EDC
	Wind resource and design wind assessment – Philippines	Jimmy Villaflor	PNOC-EDC
	Typhoons – design and additional costs	Per Norgaard	Riso
	Integration and value of wind power - Philippines	Ana Candelaria	PNOC-EDC
	Voltage stability - Sta. Ana case	Tom Cronin	Riso
	Break		
11:00	Discussion		
12:00	***Lunch***		
	Session 3: Island systems	Chaired by: Tran Thanh Lien Per Norgaard	 IE Riso
13:30	Load and wind statistics - Dinagat Island case	Jimmy Villaflor	PNOC-EDC
	Power system operation - Dinagat Island case	Jimmy Villaflor	PNOC-EDC
	Potential and value of wind power in island systems - Philippines	Ana Candelaria	PNOC-EDC
14:30	Break		
15:00	Discussion		
	Outstanding issues	Bernt Frydenberg	Mercapto
16:45	Summary of Day 2	Per Norgaard	Riso
17:00	Closing of Workshop	Tran Thanh Lien	IoE